A310-200

CF6-80A3

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ATA 70 - 72

GENERAL

Nacelle Access Panels

Access and pressure relief door-vents.

The following access doors are provided in the fan cowl :

Left fan cowl

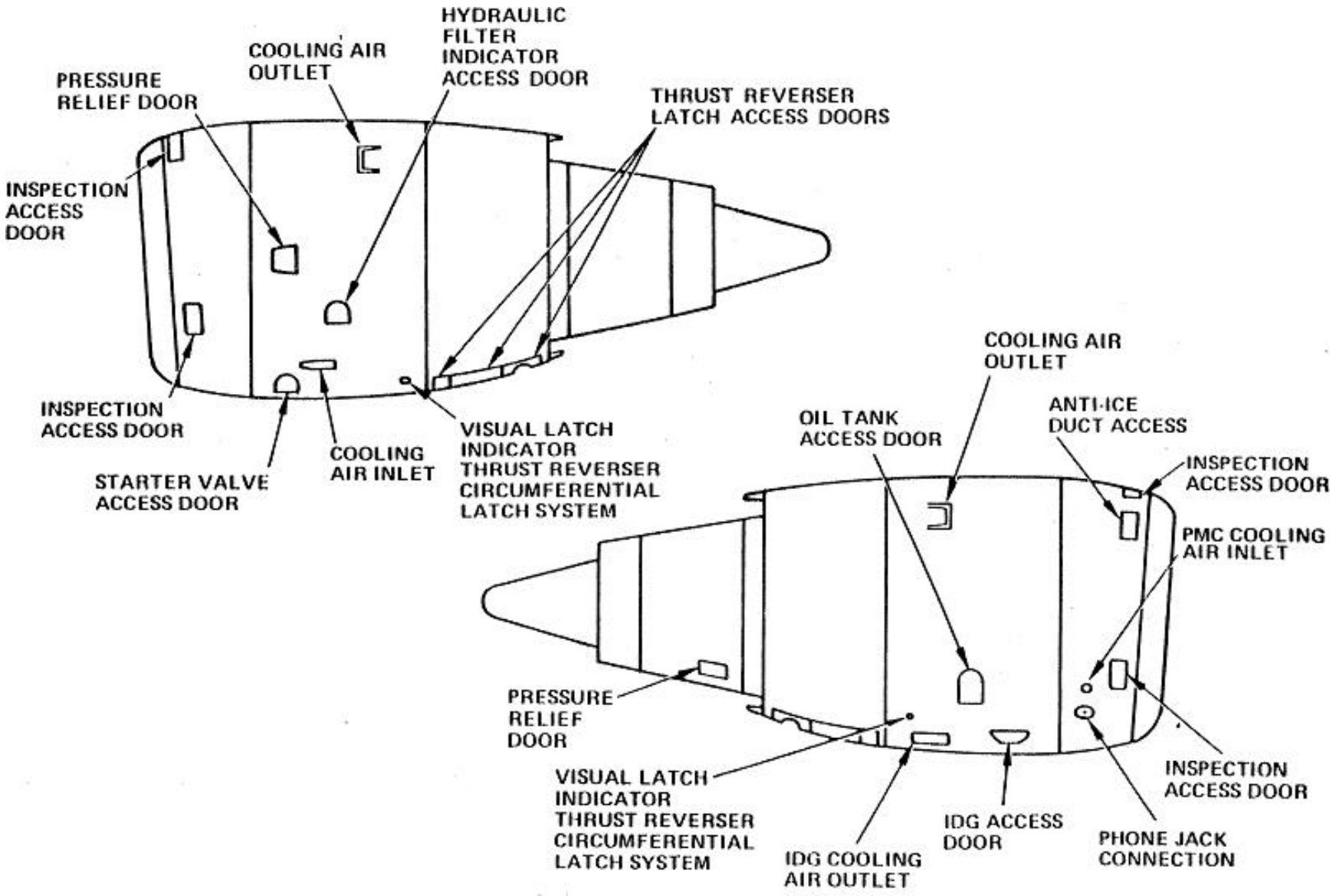
- Starter valve normal override
- Hydraulic filter
- Pressure relief door

Right fan cowl

- IDG
- Engine oil tank

In addition, a compartment cooling air inlet provides air directly toward the accessory gearbox near the hydraulic pumps.A fan reverser latch visual indicator is located in both fan cowls.

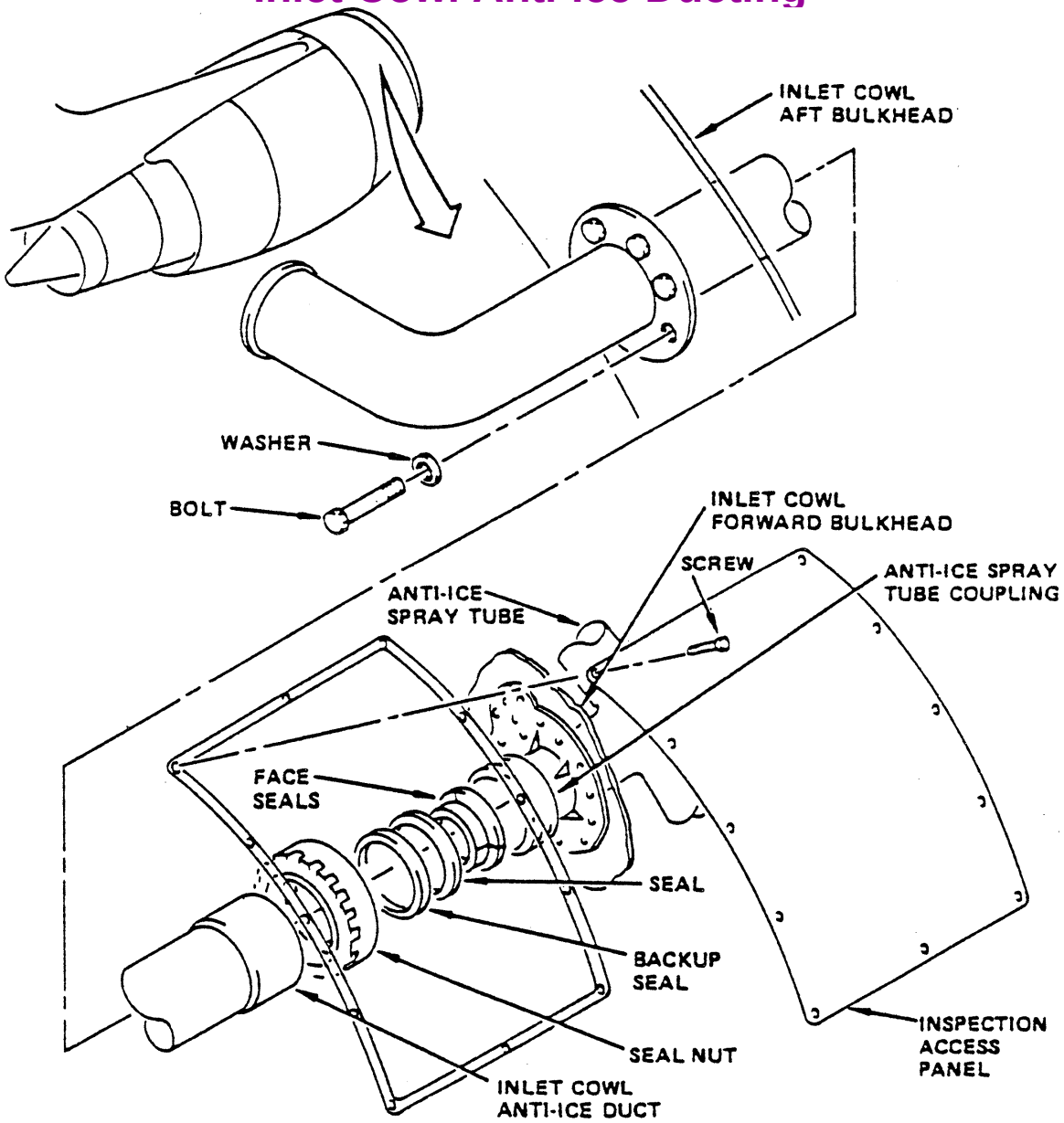
Nacelle Access Panels



Inlet Cowl Anti-Ice Ducting

The inlet cowl anti-Ice ducting is routed from the anti-Ice shutoff and regulating valve through the inlet cowl aft bulkhead, and between the inner and outer barrels of the cowl structure to the duct located in the inlet lip assembly. A slip joint is provided immediately aft of the inlet lip bulkhead to allow for duct thermal expansion.The anti-Ice duct terminates with a spray tube discharge.Hot l0th stage air flows into the inlet lip cavity through discharge holes in the spray tube. The air enters a flow passage formed by the inlet skin and bulkhead, and exits through holes located around the periphery of the inner barrel. The air exhausted into the inlet cowl aft of the inlet lip bulkhead flows between the outer and inner barrels, and is discharged overboard through an exit duct located on the bottom center-line of the inlet cowl.

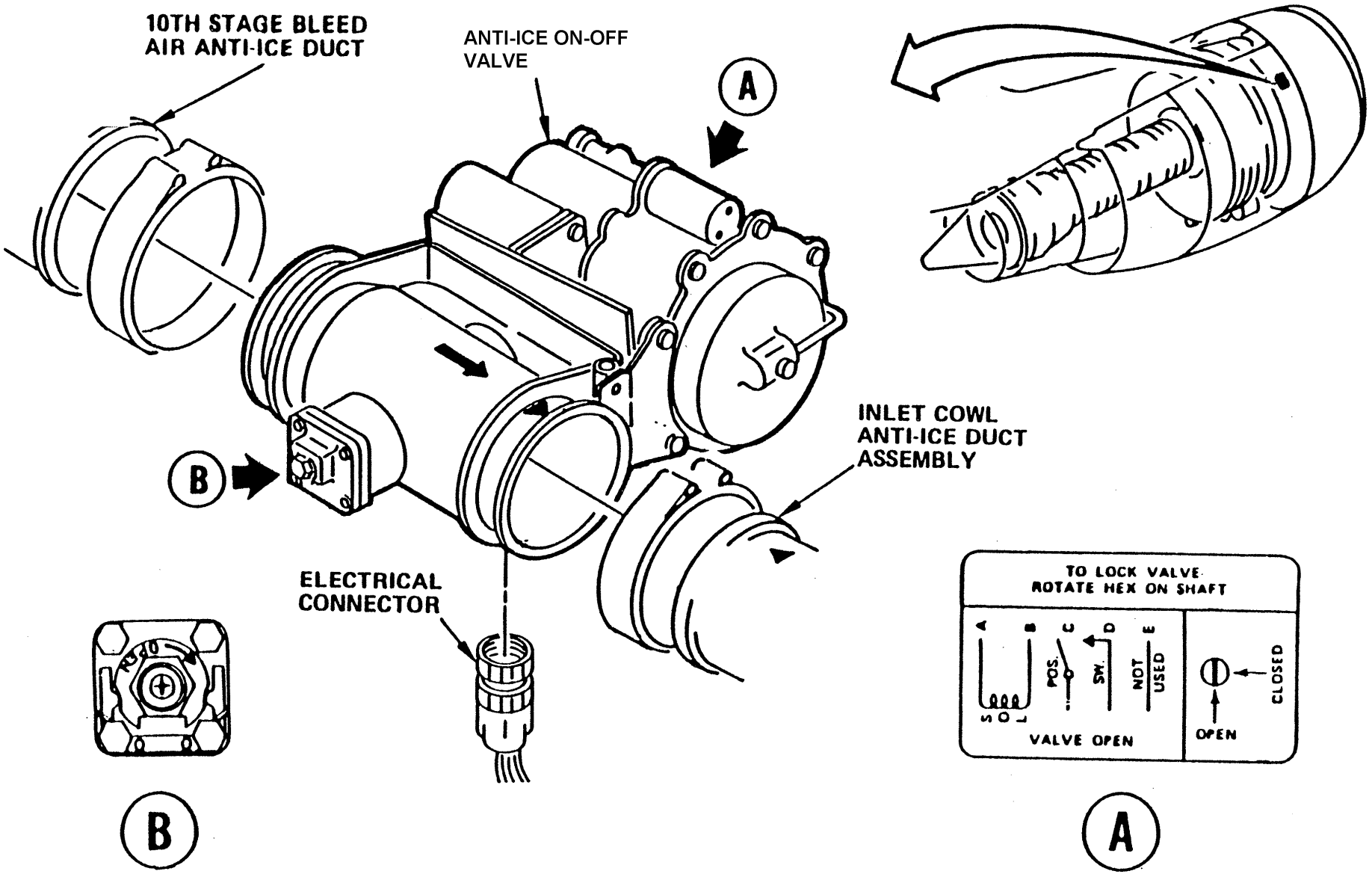
Inlet Cowl Anti-Ice Ducting



Inlet Cowl Anti-Ice Valve

The inlet cowl anti-Ice shutoff and regulating valve is a solenoid-controlled,spring loaded open, Pneumatically-operated valve. Wrench flats on the exterior of the valve permit locking the valve in either open or closed position. Force required to position the valve is less than 75 inch-pounds. A mechanical position indicator located on the valve body gives visual indication of the valve position. The valve is permanently marked with arrows on the valve body to indicate airflow direction and the correct installation position. The valve is spring loaded open and is closed by applying solenoid voltage and inlet pressure. Inlet cowl anti-Ice shutoff and regulating valve position is controlled by energizing *or* de-energizing the valve solenoid by means of a switch in the flight compartment. When the solenoid is de-energized, the valve opens and senses downstream pressure in the anti-Ice ducting and regulates the pressure between 123 and 138 psi.

Inlet Cowl Anti-Ice Valve



Inlet Cowl Anti-Ice Overpressure Indicator

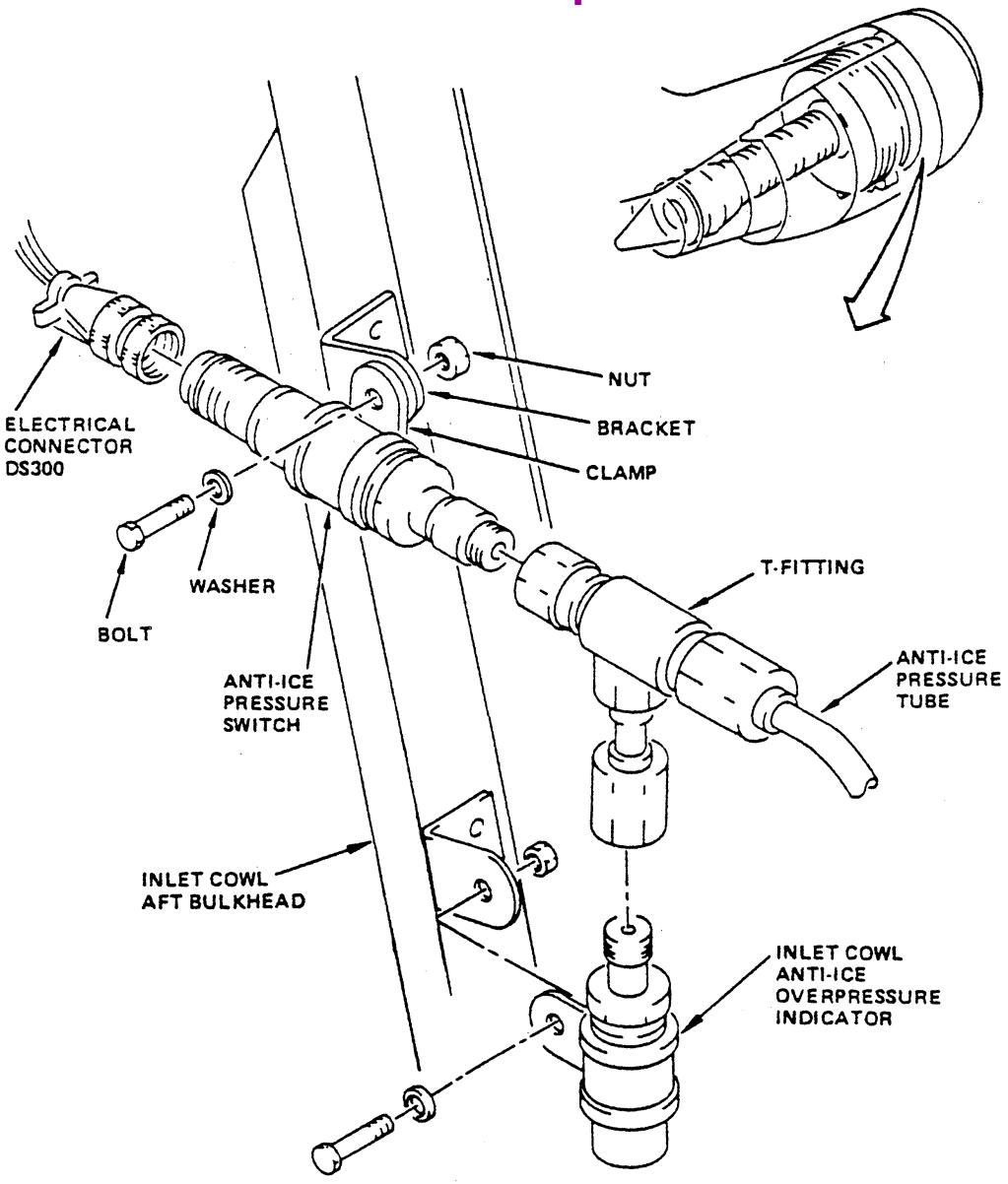
Anti-Ice Pressure Switch

The anti-Ice pressure switch is a single-pole sealed unit installed in the anti-Ice duct sense line. The switch actuates at an increasing pressure of 85 psi maximum and a decreasing pressure of 70 psi minimum. When the control switch for the cowl anti-Ice is placed in the "ON" position, the shutoff and regulating valve opens, allowing pressure to build up in the anti-icing ducting. This pressure build up actuates the anti-Ice pressure switch and causes the respective engine anti-Ice system "ON" light to illuminate in the flight compartment.

Anti-Ice Visual Overpressure Indicator

The anti-Ice visual overpressure indicator is a pop-up type pressure sensor connected to the downstream side of the anti-Ice shutoff and regulating valve. The visual indicator is a red button that pops out if the duct pressure exceeds 190 +/- 10 psi . After having been tripped. the button will stay out under all conditions until it is manually reset. The unit may be easily reset with finger pressure when no inlet pressure exists.

Inlet Cowl Anti-Ice Overpressure Indicator

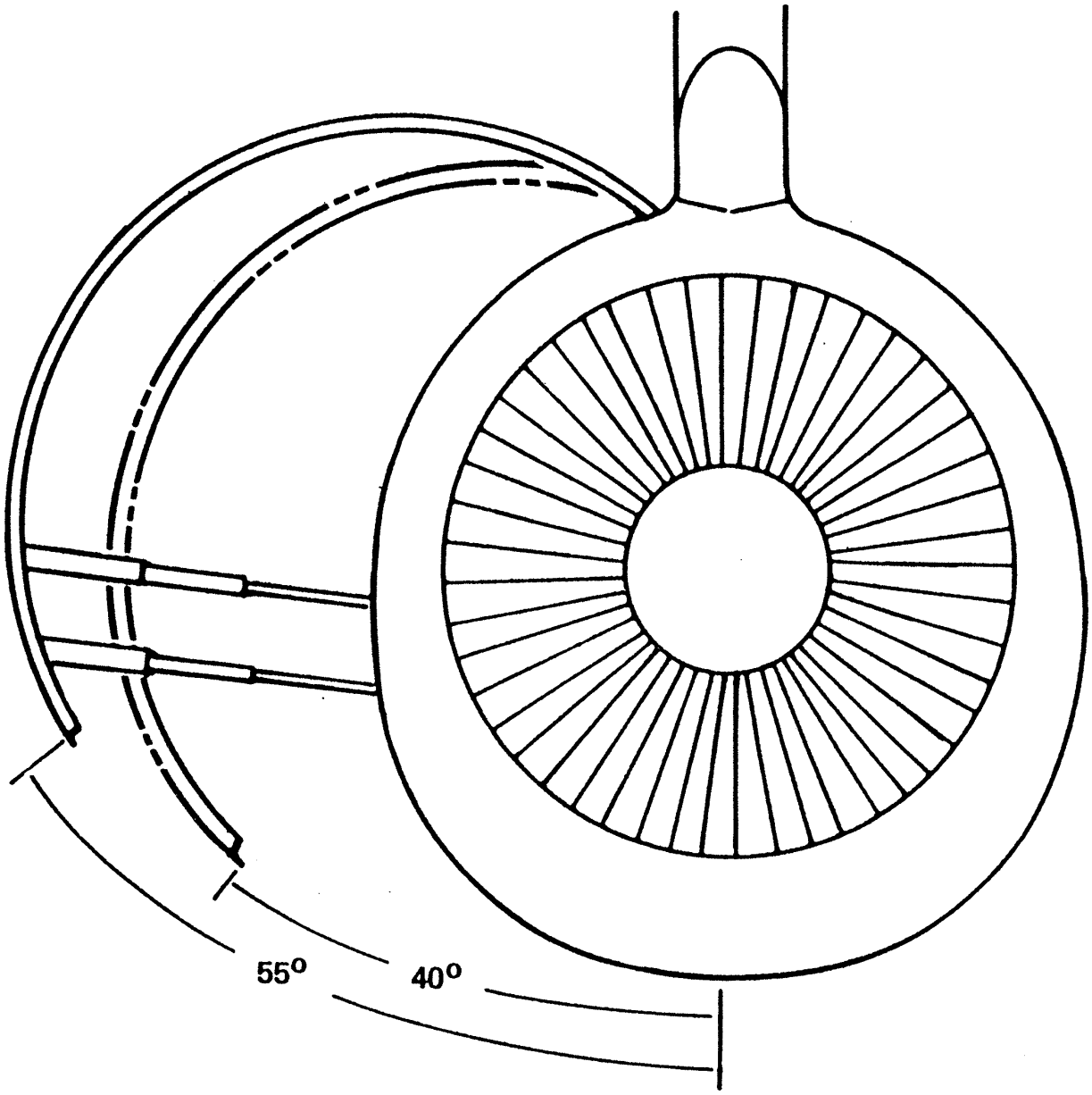


Fan Cowl Door

Two hold-open rods are attached at one end to the lower inside surface of each fan cowl door.
The free ends of the rods are stowed in clips on the inside of the door when not in use. The hold-open rods engage detents on the fan case, and may be extended to hold the door in either the 40 degree open position or the 55 degree open position.

Hardpoints and nutplates have been incorporated at three places in the upper part of the exterior skin of each fan cowl door for installation of sling-attach pads. The pads are installed as needed to aid removal, installation, or handling of the fan cowl door. Filler plugs are installed in the nutplates when the pads are not in use.

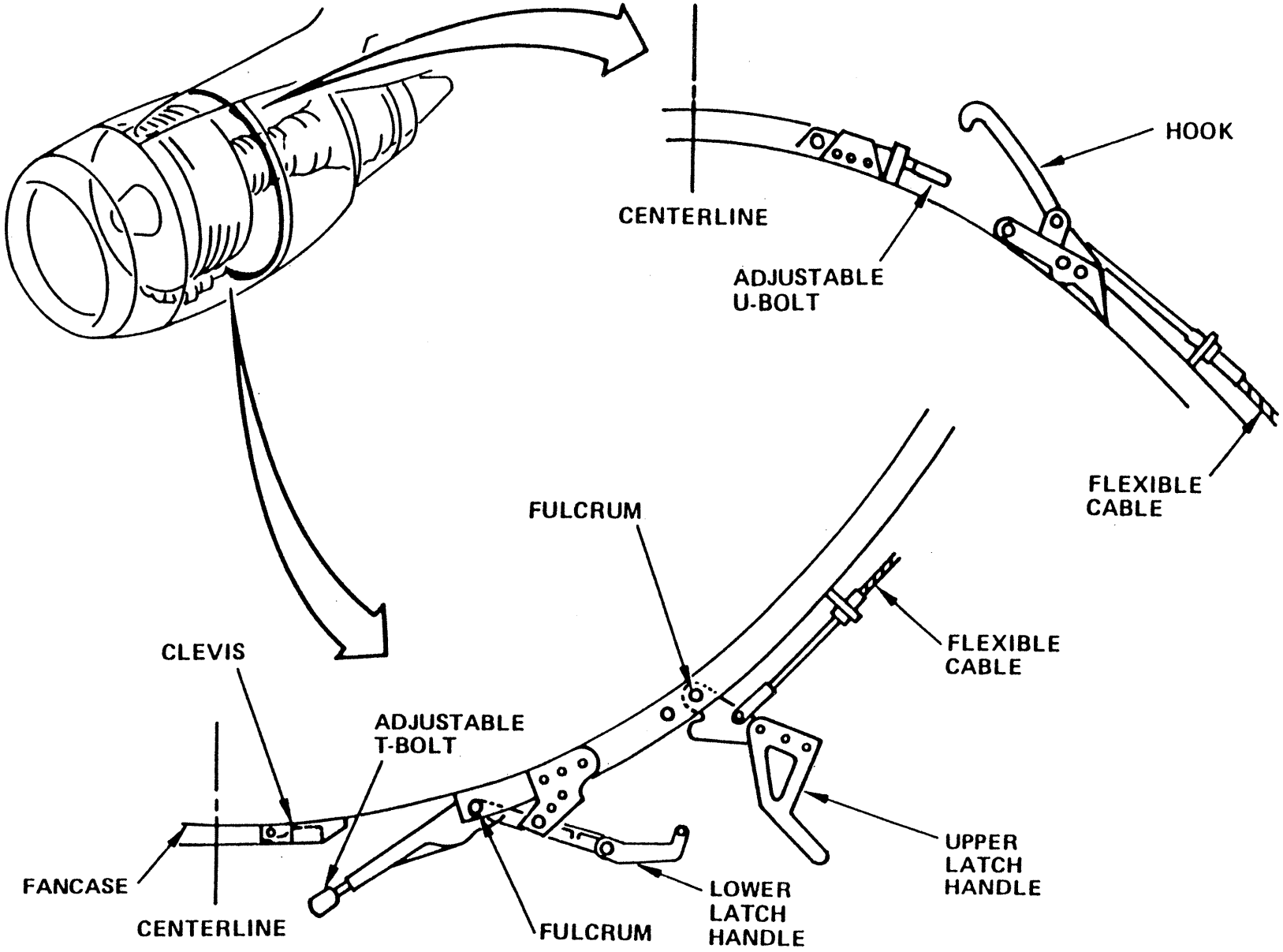
Fan Cowl Door



Thrust Reverser Mounting Ring Latch Assembly

The mounting latch assembly secures the outer leading edge of the fan reverser cowls to the aft flange of the fan frame case and transmits reverser loads into fan frame and not to hinges in pylon area. The top latch of the mounting ring is a hook that slips into a "U" bolt on top of the fan frame case. The "U" bolt is adjustable to control upper latching force. The bottom latch is a barrel nut that fits into a "claw" type clevis at the bottom of the fan frame case. The barrel unit is adjustable to control latching force.

Thrust Reverser Mounting Ring Latch Assembly

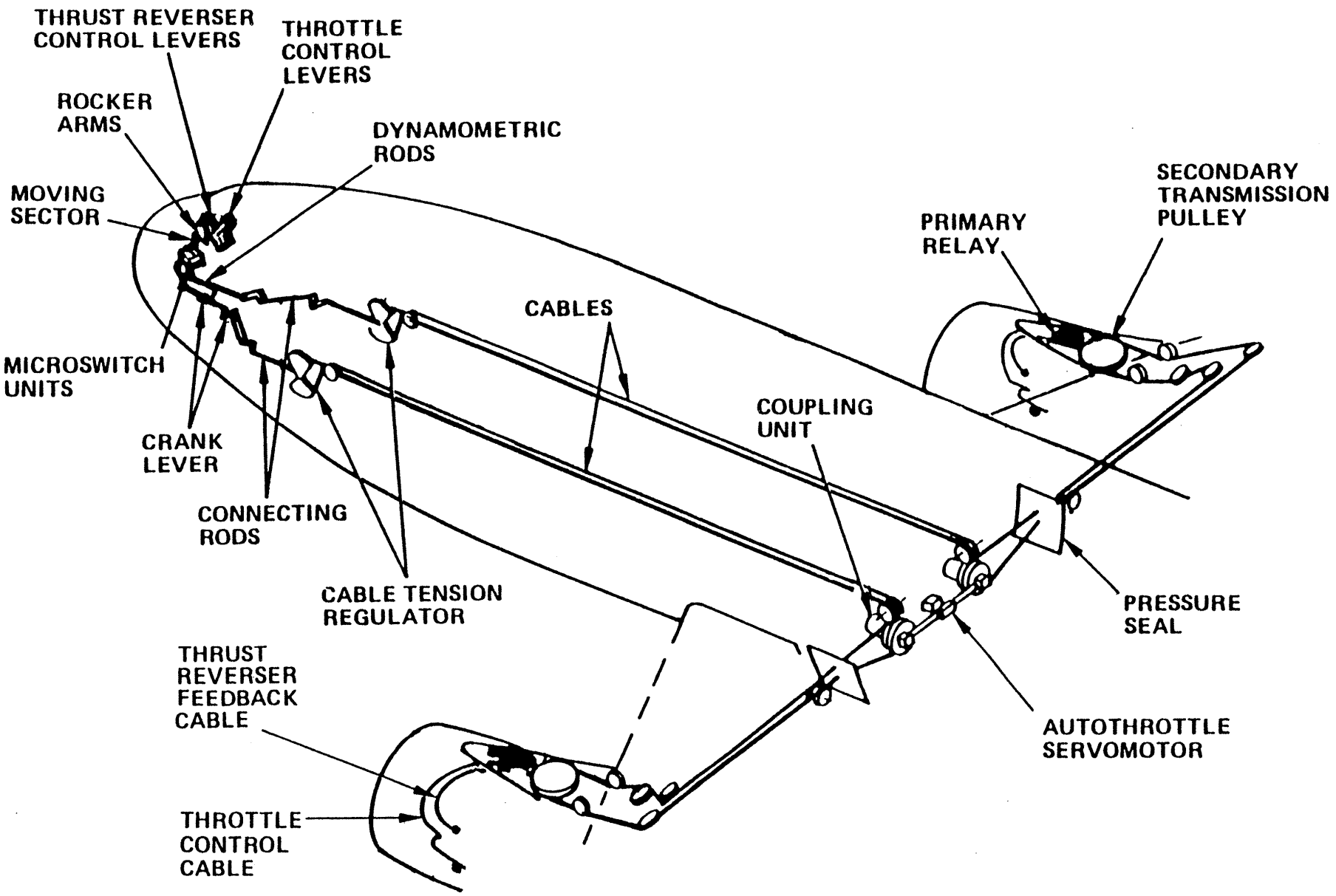


Throttle Control Mechanism

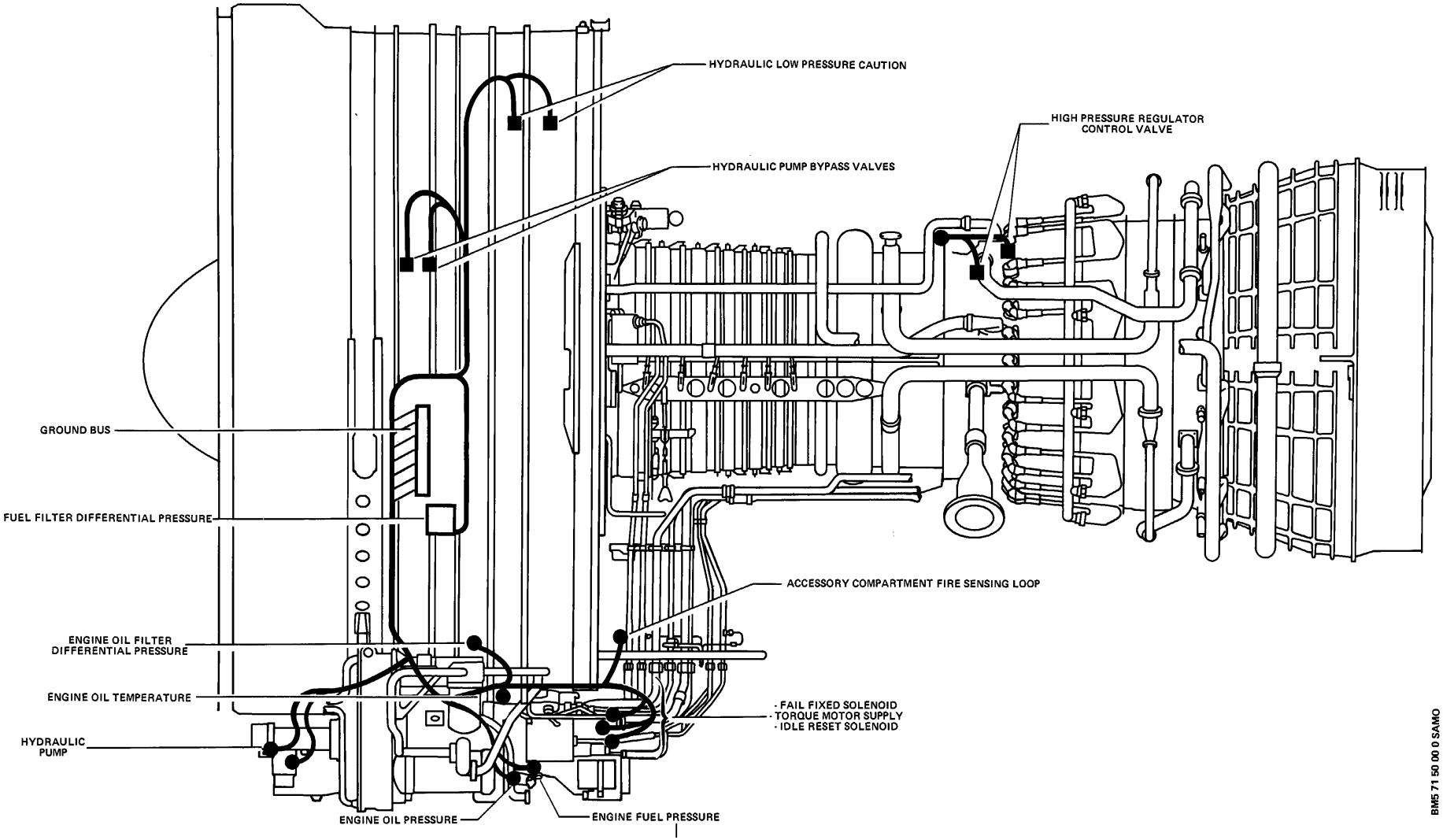
Throttle Control Mechanical Part

Forward displacement of the throttle control lever results in displacement of the dynamometric rod and rotation of the bellcrank. Rotation of the bellcrank transmits the movement to a linkage (rods, bellcranks), which in turn rotate a quadrant on which is wound the control cable. After the quadrant, the cable is routed in the cargo compartment, up to the wing root.The autothrottle coupling unit has the function of a bellcrank and directs the cable towards the leading edge, at pylon-to-wing attach fitting level, where the secondary relay is located.The secondary relay consists of a pulley driven by the cable and is fitted with a pin to which a control rod is attached.This rod sets into movement the primary transmission crank lever which is connected to a CABLECRAFT flexible push-pull control routed on the fan case periphery. By means of a rod system, the cable displaces the power lever located on the MEC.

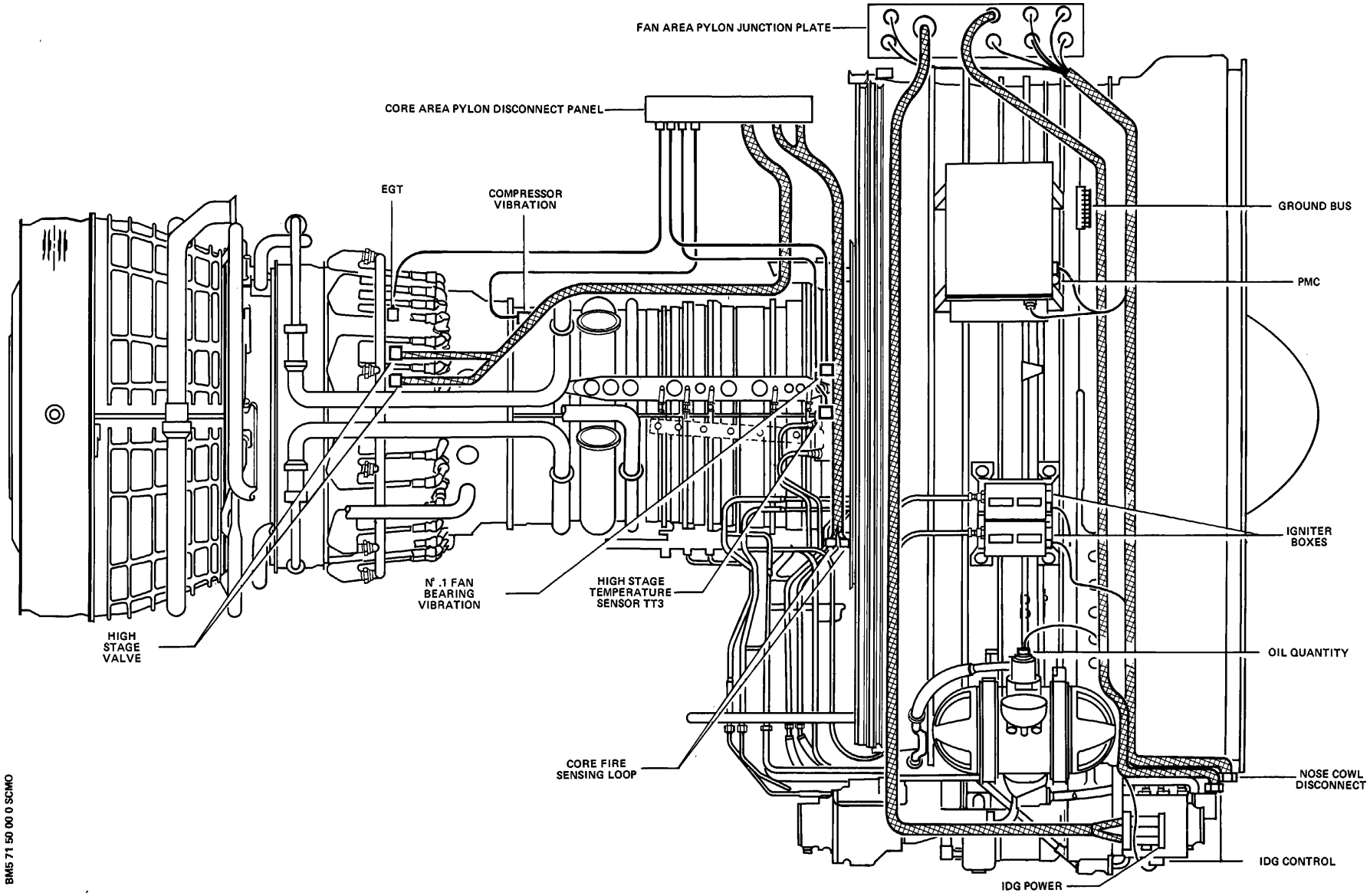
Throttle Control Mechanism



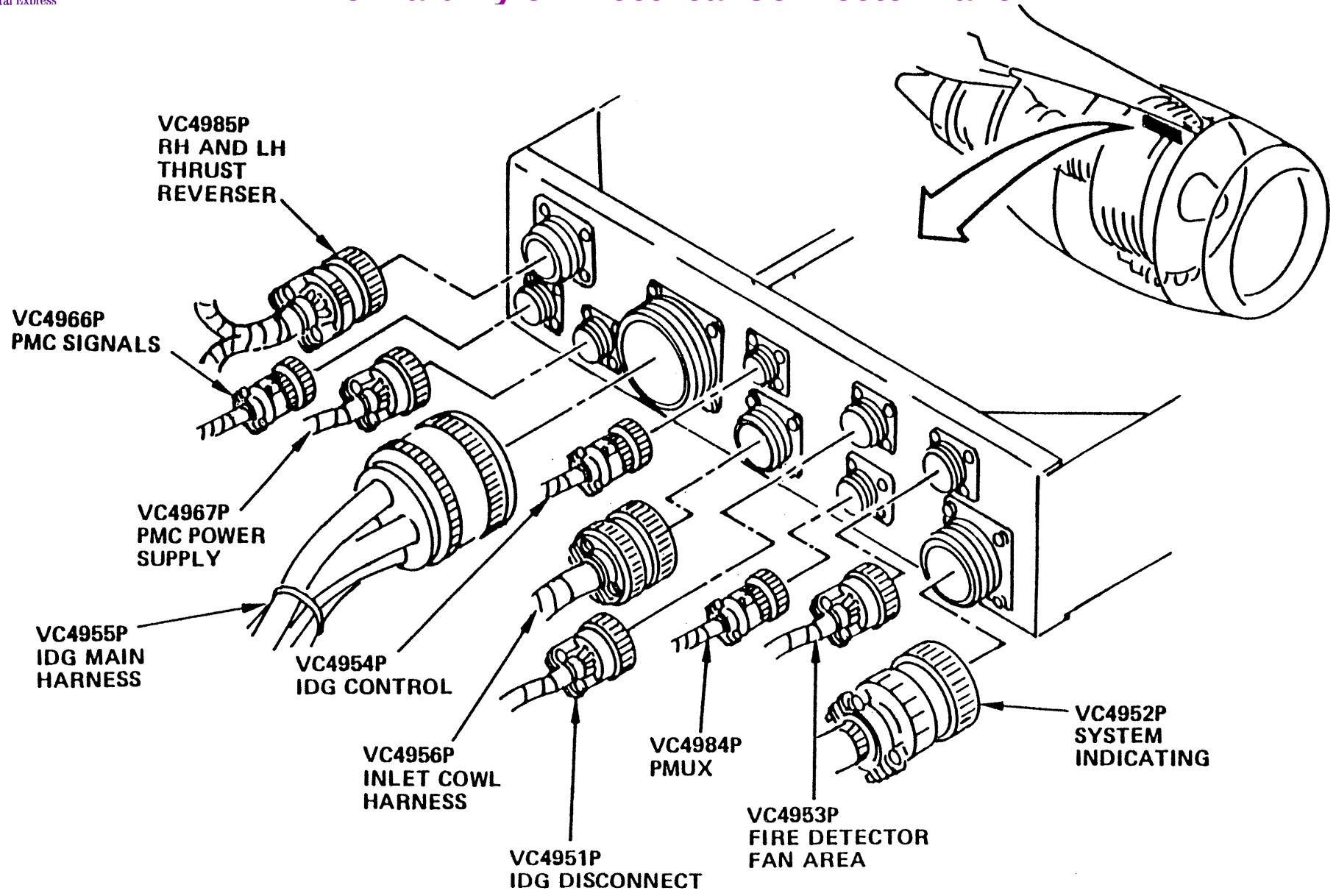
Electrical System - LH Side



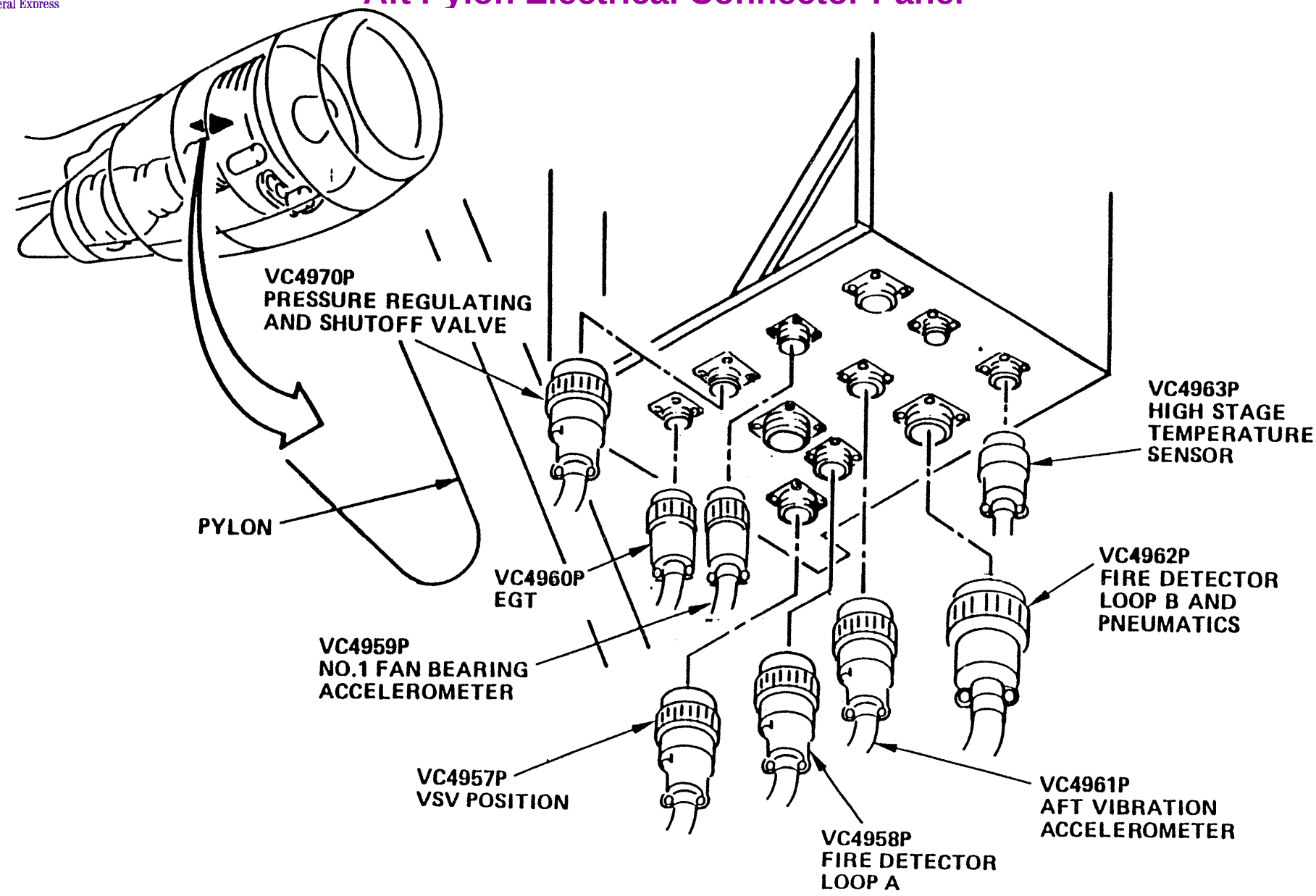
Electrical System - RH Side



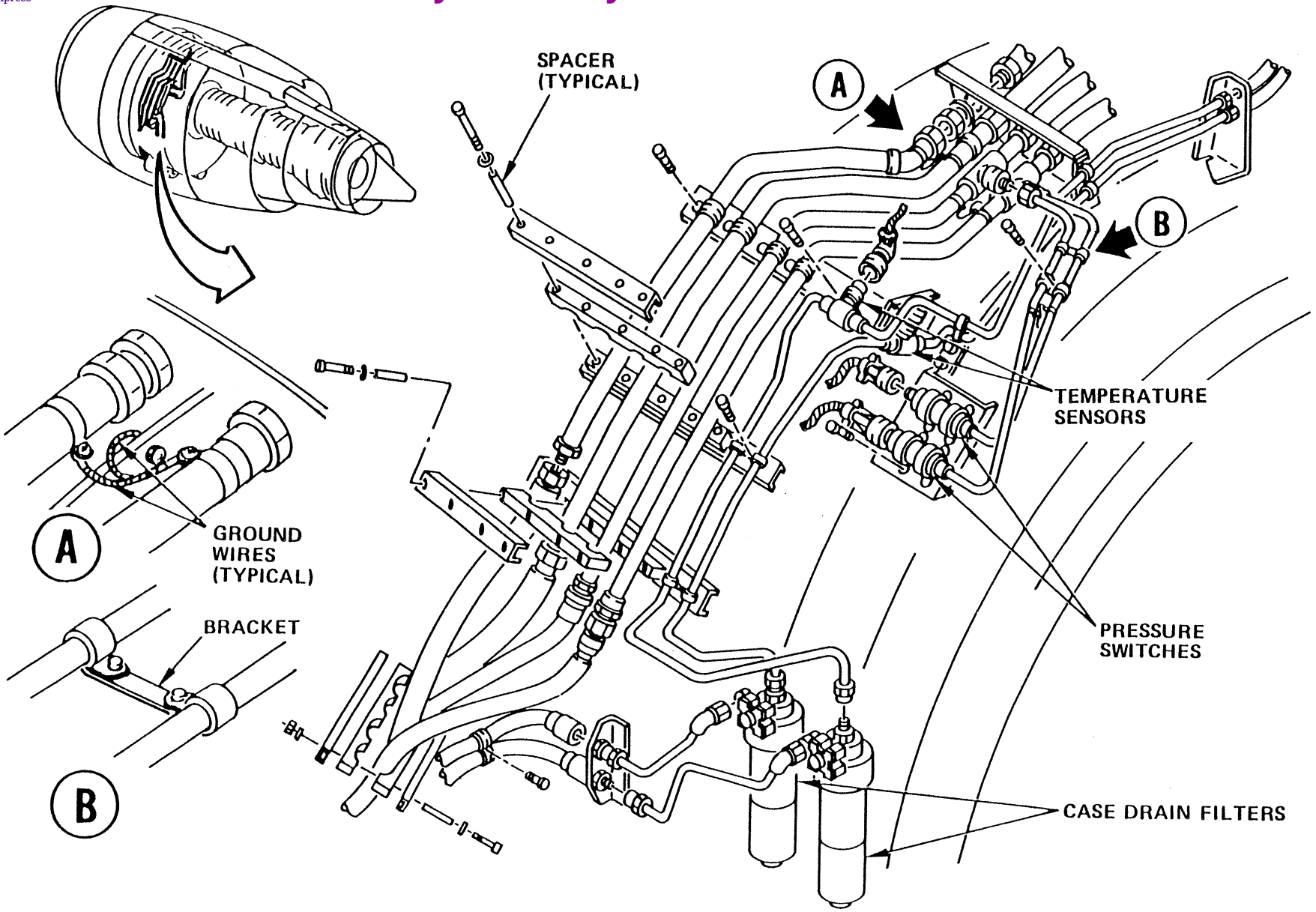
Forward Pylon Electrical Connector Panel



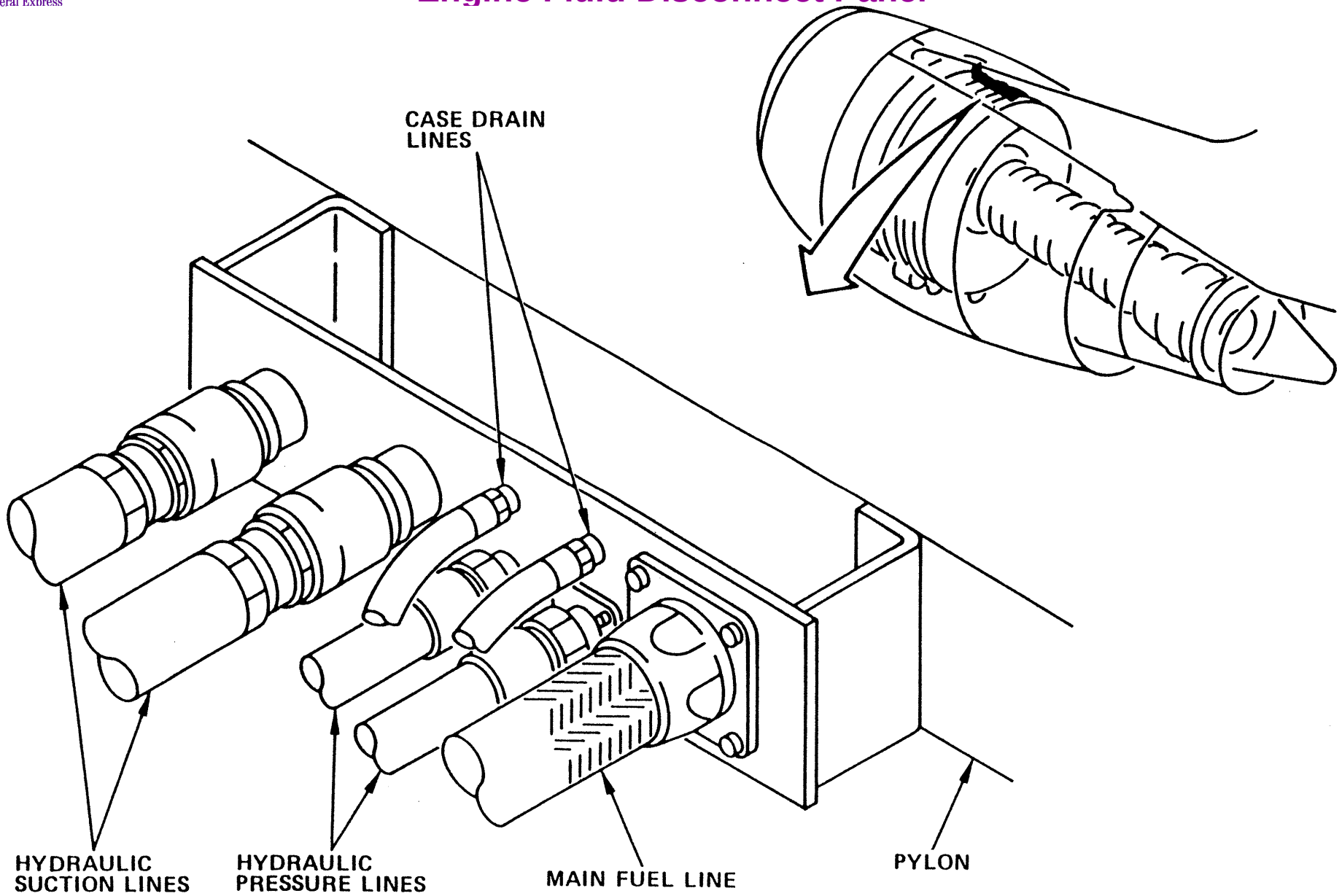
Aft Pylon Electrical Connector Panel



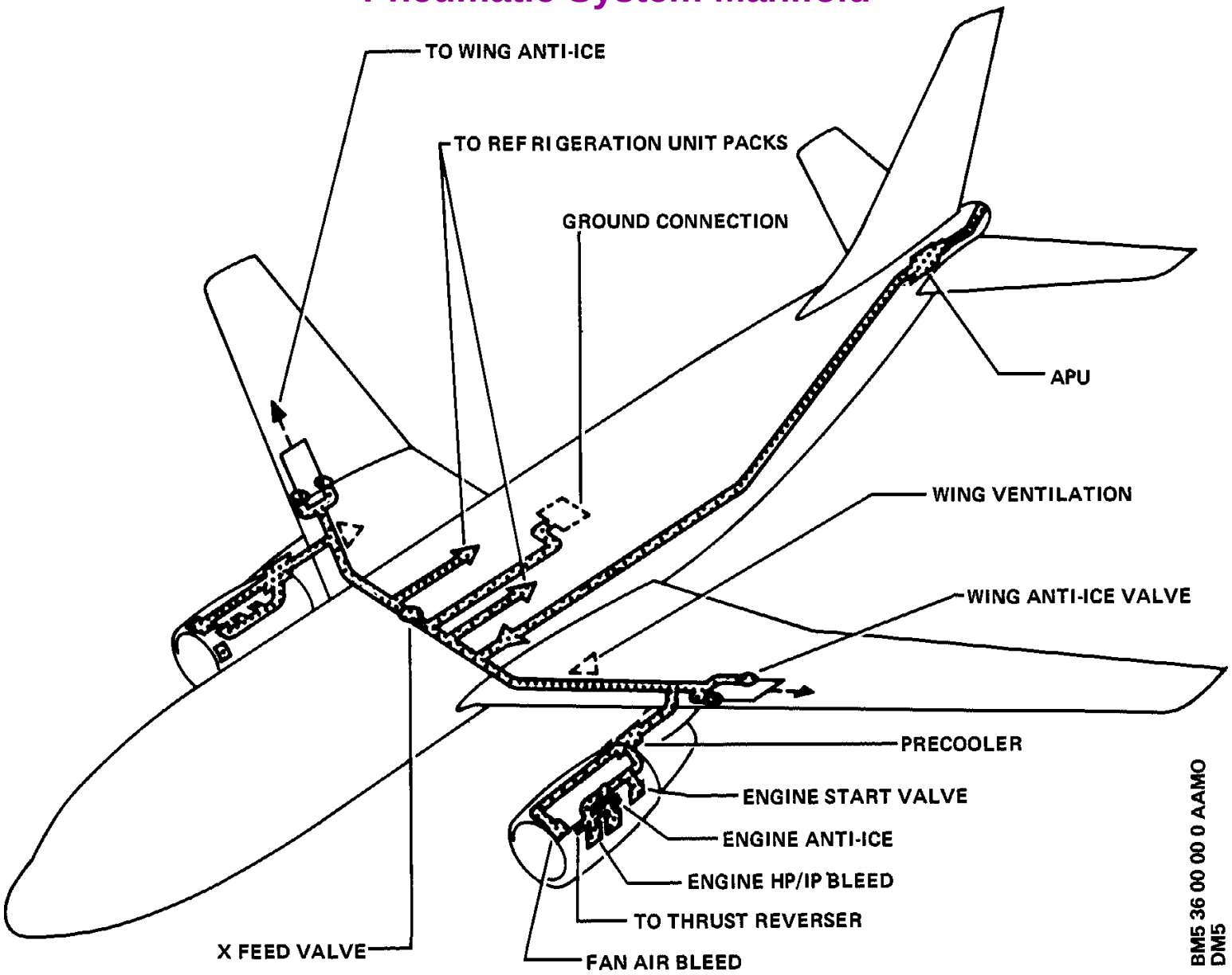
Hydraulic System Installation



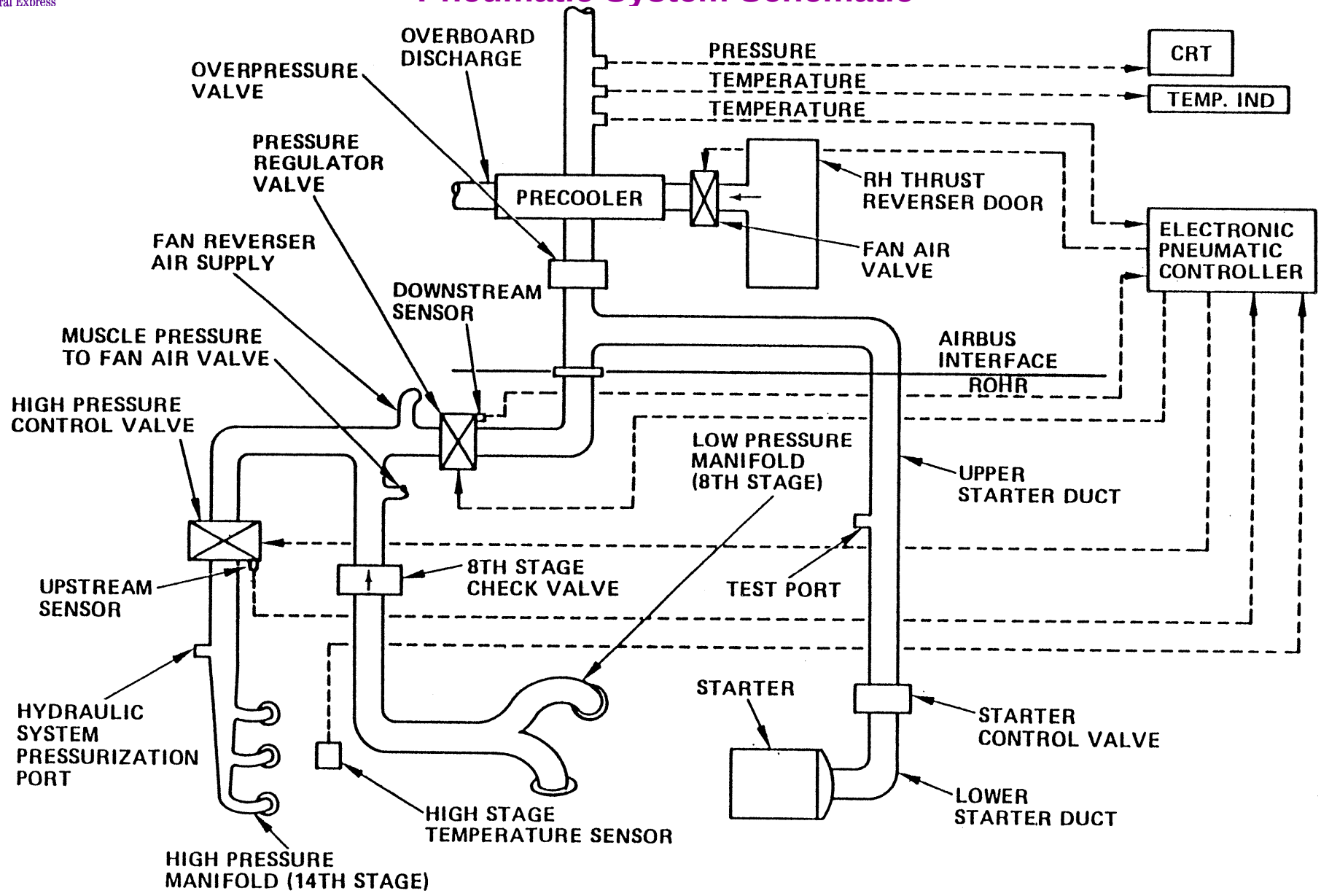
Engine Fluid Disconnect Panel



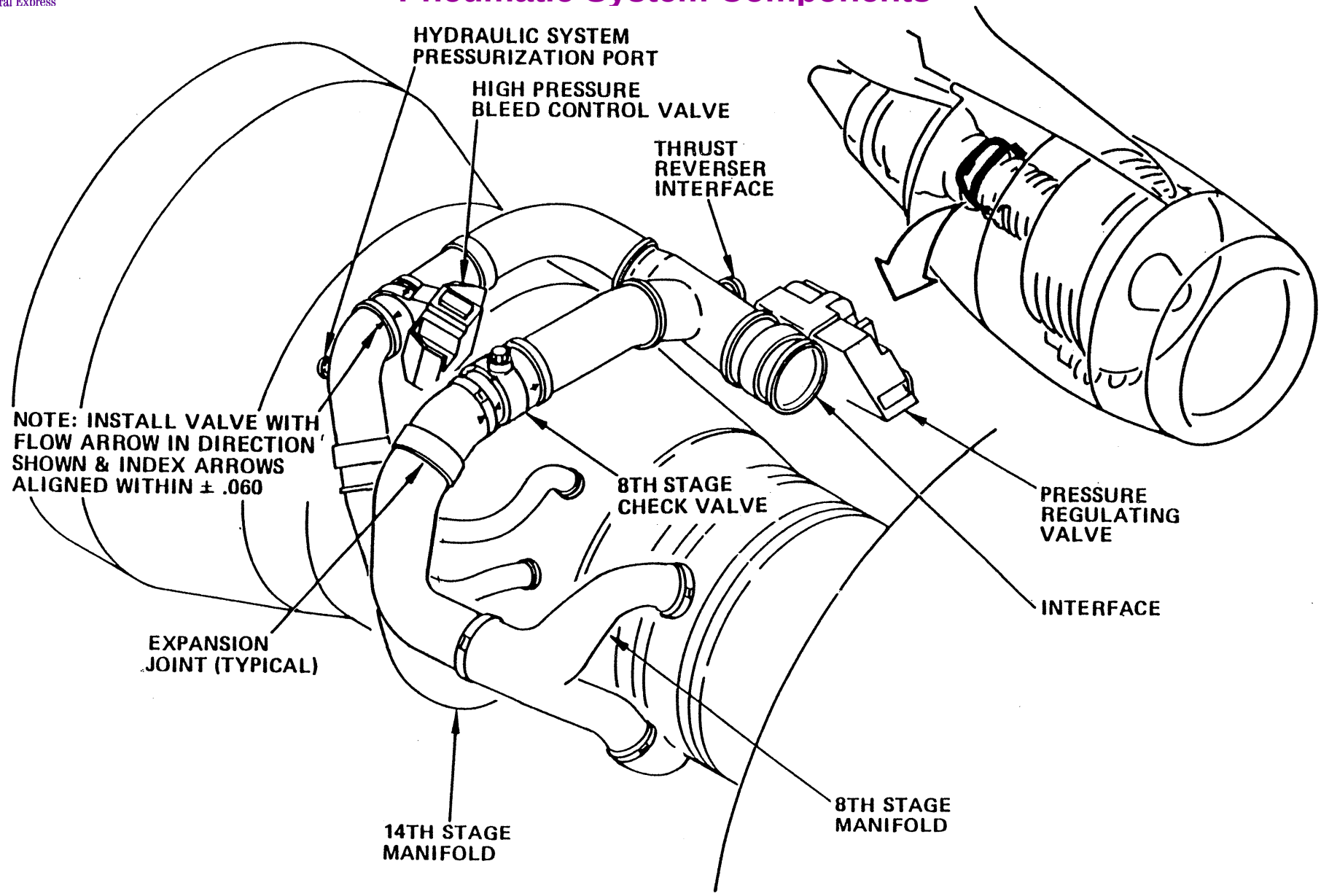
Pneumatic System Manifold



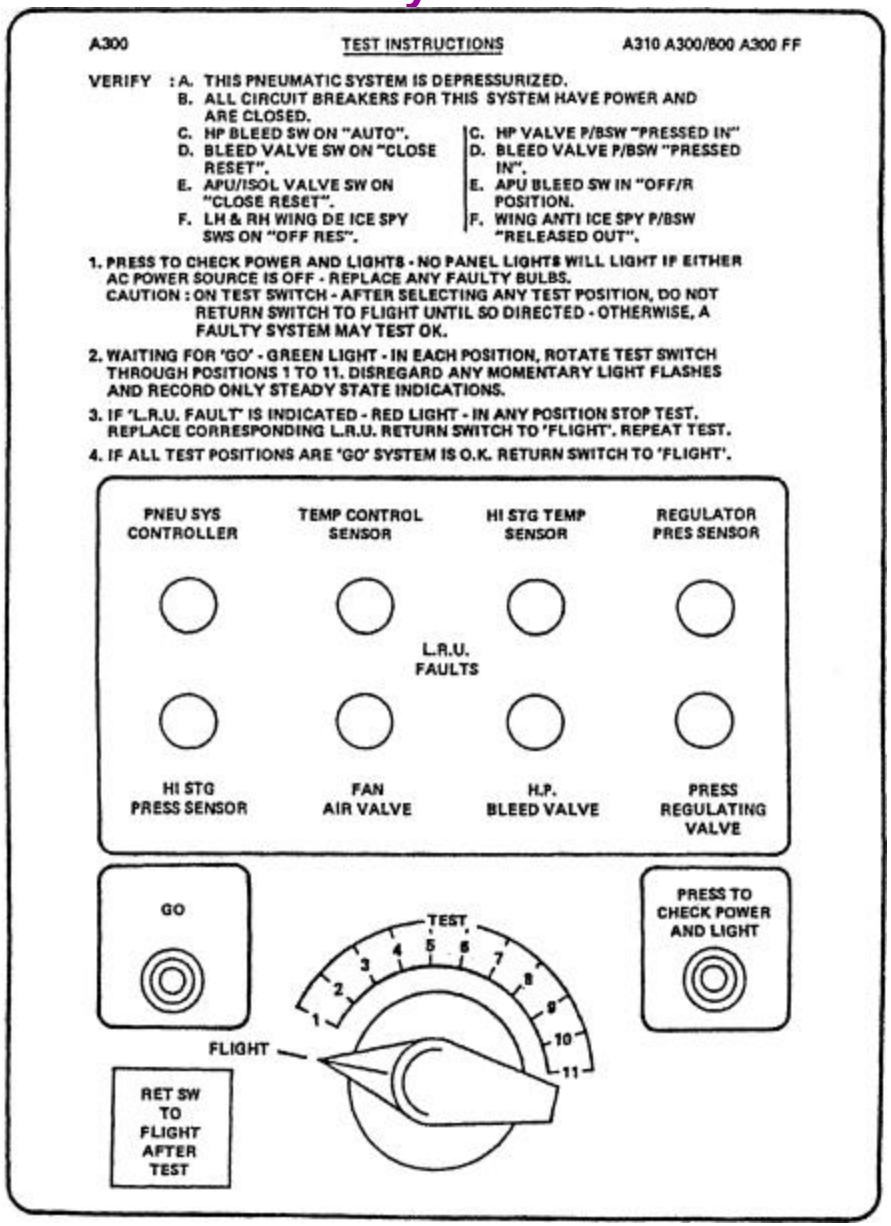
Pneumatic System Schematic



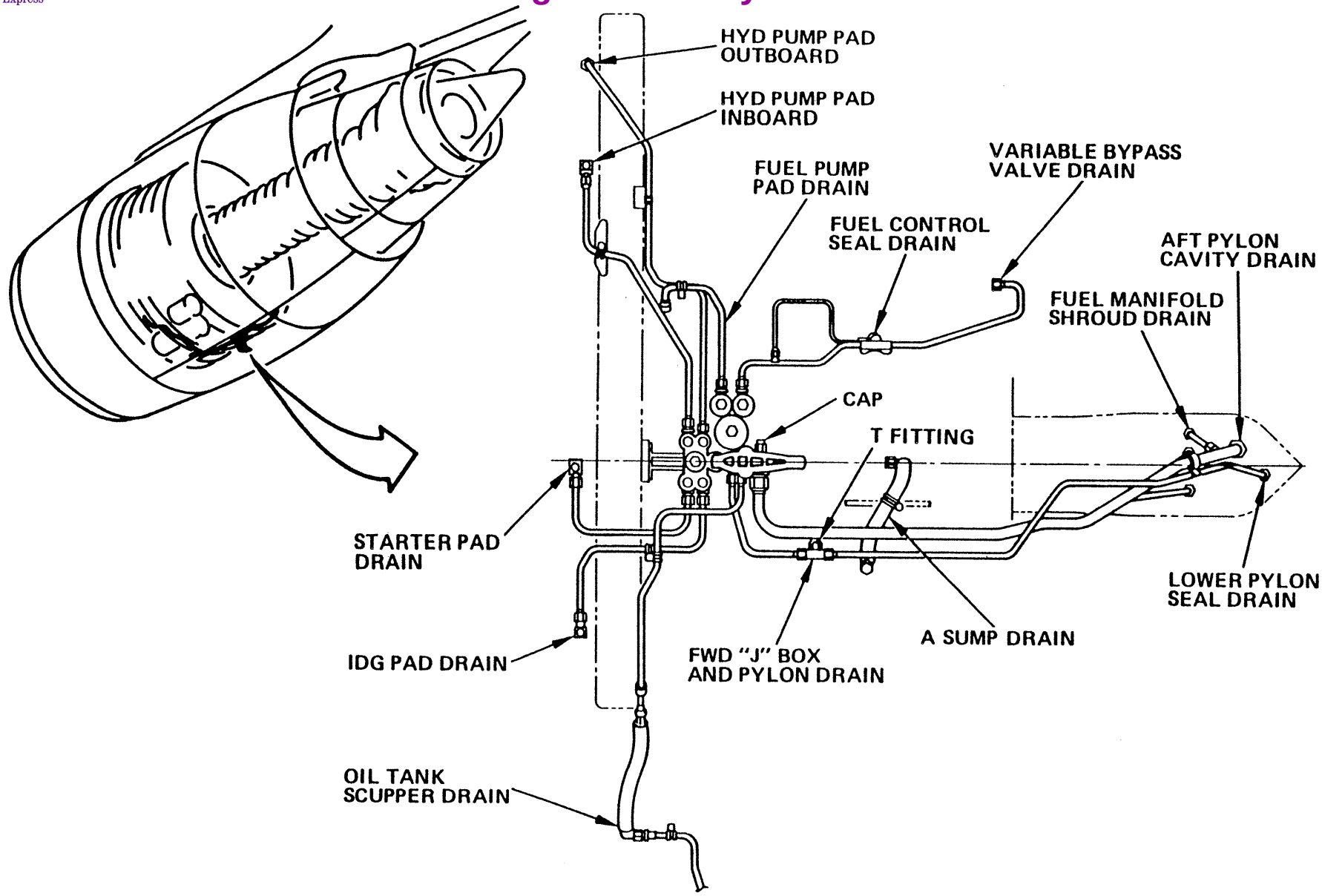
Pneumatic System Components


HYDRAULIC SYSTEM PRESSURIZATION PORT
HIGH PRESSURE BLEED CONTROL VALVE
THRUST REVERSER INTERFACE
NOTE: INSTALL VALVE WITH FLOW ARROW IN DIRECTION SHOWN & INDEX ARROWS ALIGNED WITHIN ± .060
8TH STAGE CHECK VALVE
PRESSURE REGULATING VALVE
INTERFACE
EXPANSION JOINT (TYPICAL)
14TH STAGE MANIFOLD
8TH STAGE MANIFOLD

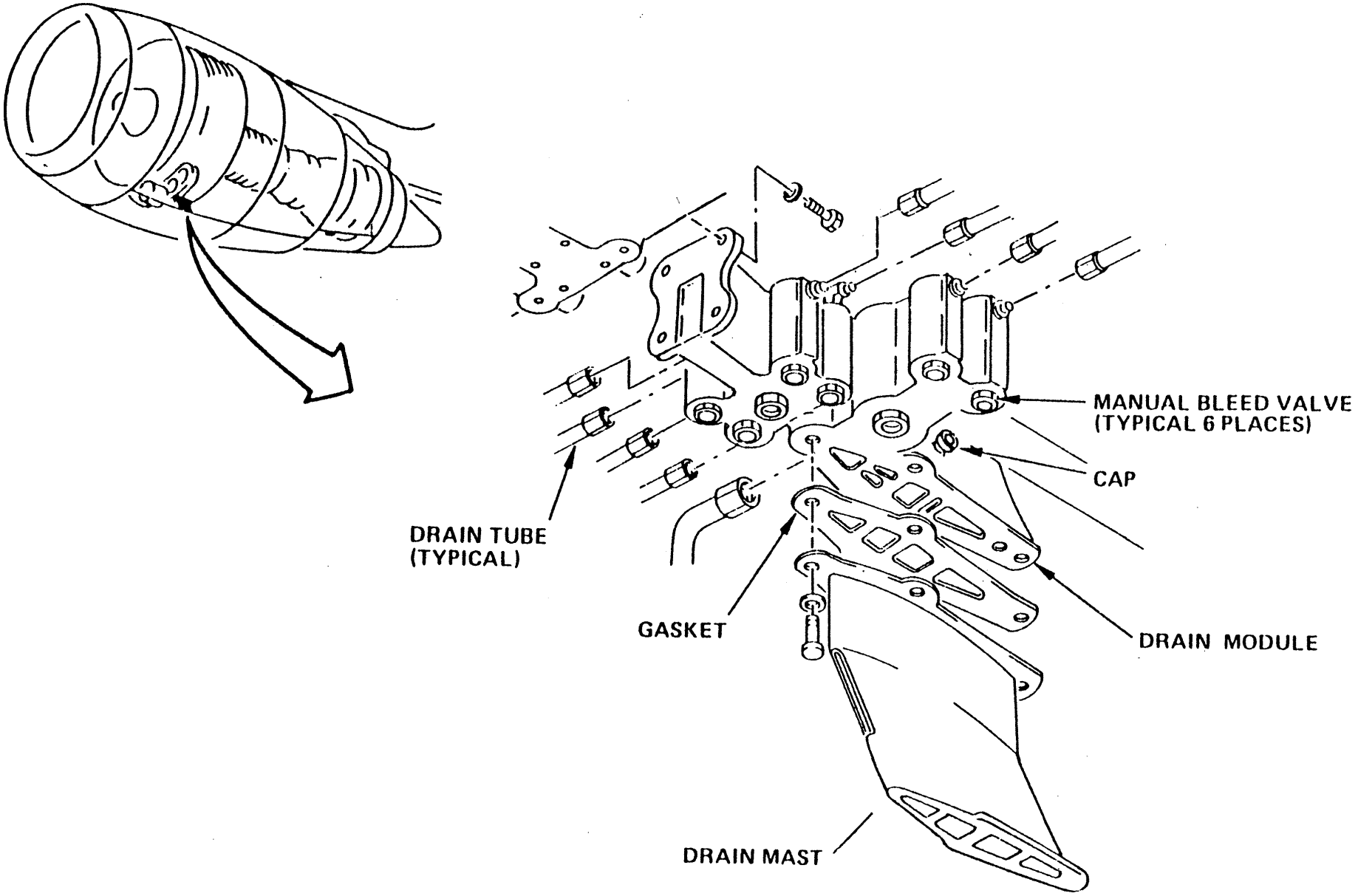
Pneumatic System BITE Test


A300
TEST INSTRUCTIONS
A310 A300/600 A300 FF
VERIFY : A. THIS PNEUMATIC SYSTEM IS DEPRESSURIZED.
B. ALL CIRCUIT BREAKERS FOR THIS SYSTEM HAVE POWER AND ARE CLOSED.
C. HP BLEED SW ON "AUTO".
D. BLEED VALVE SW ON "CLOSE RESET".
E. APU/ISOL VALVE SW ON "CLOSE RESET".
F. LH & RH WING DE ICE SPY SWS ON "OFF RES".
C. HP VALVE P/BSW "PRESSED IN"
D. BLEED VALVE P/BSW "PRESSED IN".
E. APU BLEED SW IN "OFF/R POSITION.
F. WING ANTI ICE SPY P/BSW "RELEASED OUT".
1. PRESS TO CHECK POWER AND LIGHTS - NO PANEL LIGHTS WILL LIGHT IF EITHER AC POWER SOURCE IS OFF - REPLACE ANY FAULTY BULBS.
CAUTION : ON TEST SWITCH - AFTER SELECTING ANY TEST POSITION, DO NOT RETURN SWITCH TO FLIGHT UNTIL SO DIRECTED - OTHERWISE, A FAULTY SYSTEM MAY TEST OK.
2. WAITING FOR 'GO' - GREEN LIGHT - IN EACH POSITION, ROTATE TEST SWITCH THROUGH POSITIONS 1 TO 11. DISREGARD ANY MOMENTARY LIGHT FLASHES AND RECORD ONLY STEADY STATE INDICATIONS.
3. IF 'L.R.U. FAULT' IS INDICATED - RED LIGHT - IN ANY POSITION STOP TEST. REPLACE CORRESPONDING L.R.U. RETURN SWITCH TO 'FLIGHT'. REPEAT TEST.
4. IF ALL TEST POSITIONS ARE 'GO' SYSTEM IS O.K. RETURN SWITCH TO 'FLIGHT'.
PNEU SYS CONTROLLER
TEMP CONTROL SENSOR
HI STG TEMP SENSOR
REGULATOR PRES SENSOR
L.R.U. FAULTS
HI STG PRESS SENSOR
FAN AIR VALVE
H.P. BLEED VALVE
PRESS REGULATING VALVE
GO
TEST
1
2
3
4
5
6
7
8
9
10
11
FLIGHT
PRESS TO CHECK POWER AND LIGHT
RET SW TO FLIGHT AFTER TEST

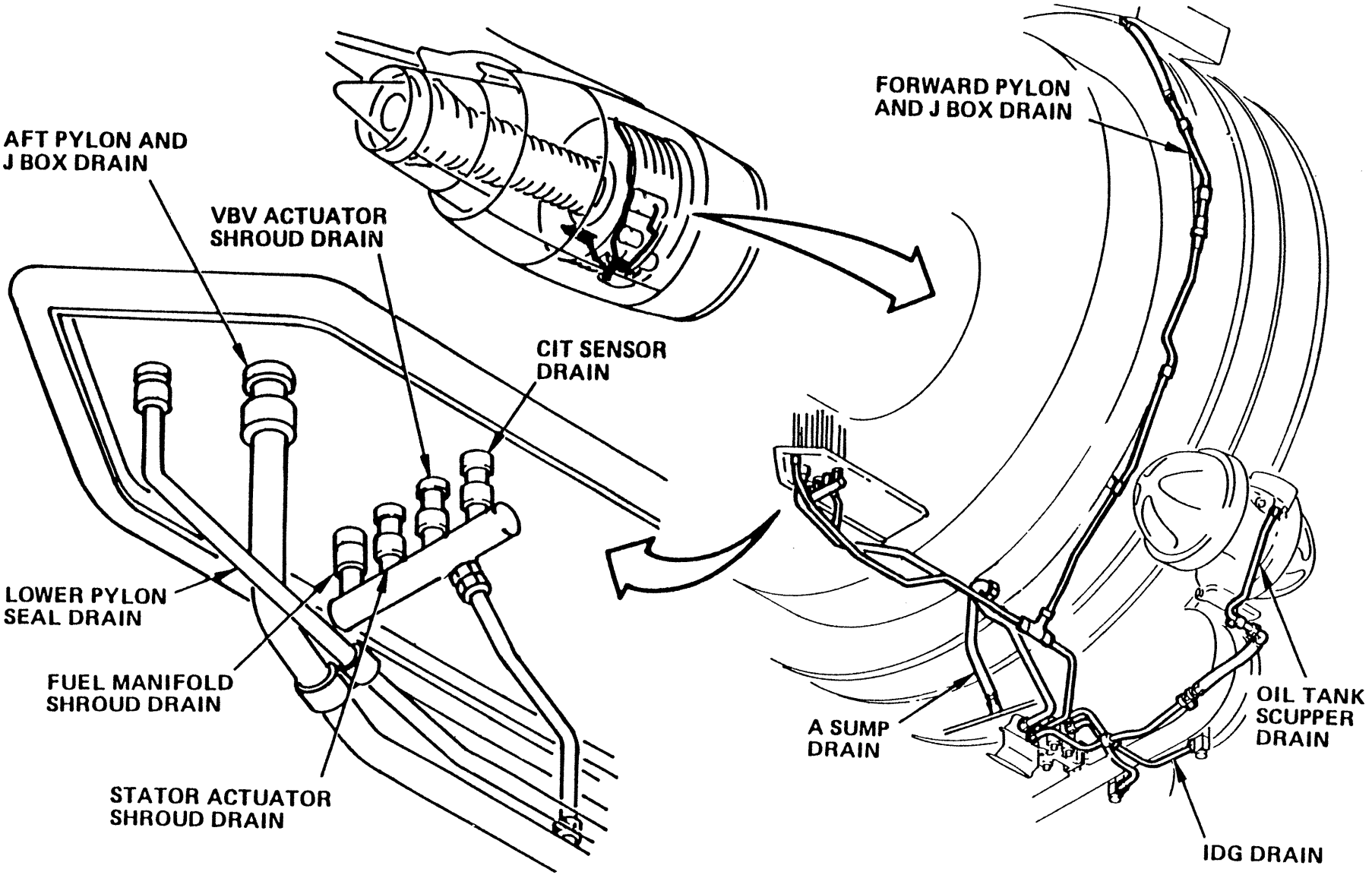
Engine Drain System



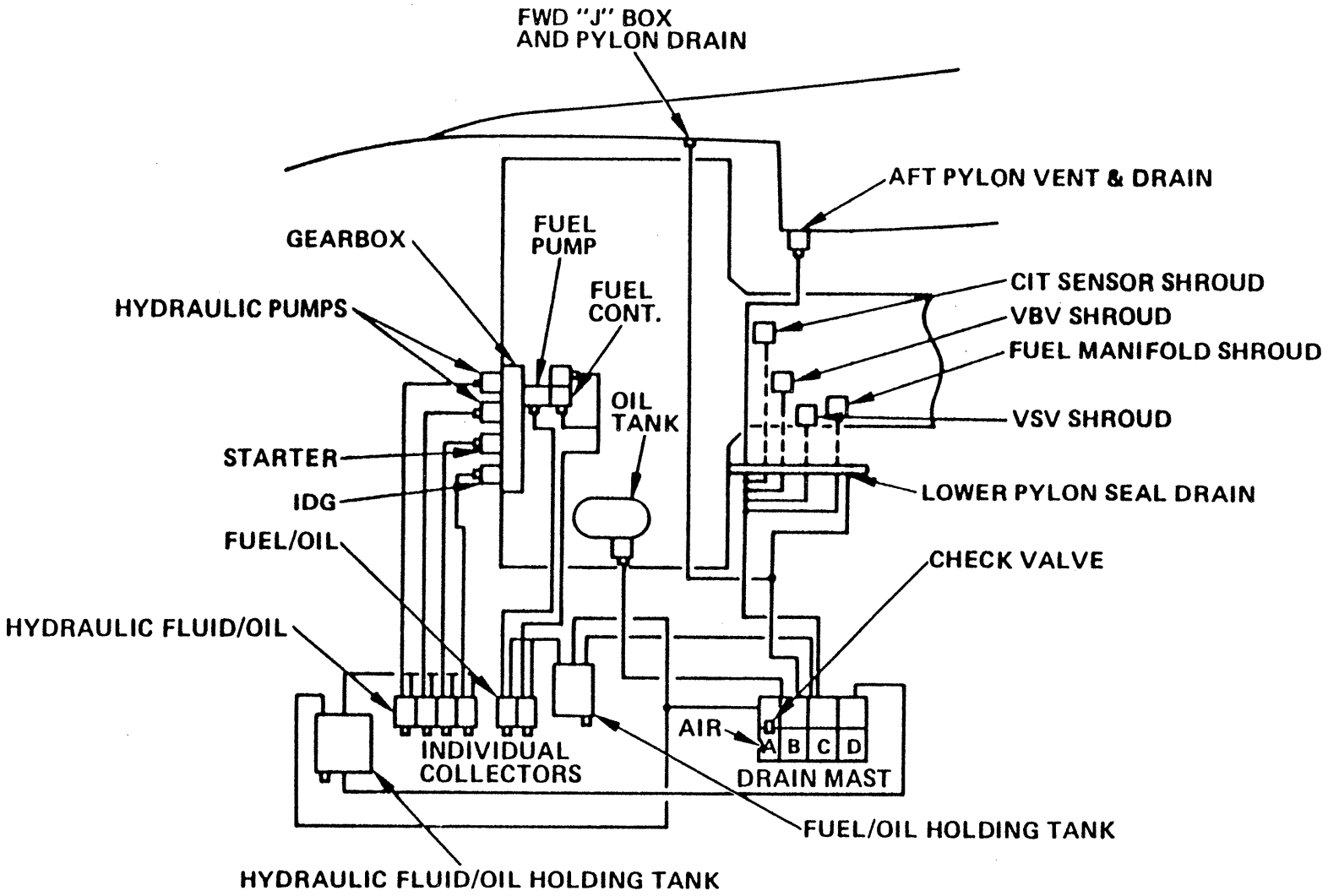
Engine Drain Module and Mast



Engine Drain System Mode - Right Side



Engine Drain System Diagram



Engine Characteristics

The CF6-80 engine is a development of the CF6-50 engine. The engines are in approximately the same thrust class. The differences are in the design changes due to the desire to reduce length (cowl drag), reduce engine weight, increase efficiency, improve strength, and reduce maintenance costs.

The aircraft application determines which CF6-80 model is used. The Boeing B767 has installed the CF6-80A/A2 engine, while the Airbus Industrie A310 has the the CF6.80AI/A3 installed. The differences are in~e location of the accessory gearbox. The CF6-80A1 A2 has a core engine mounted gearbox which makes possible a small inlet lip which is more efficient aerodynamically. The C*80A1/A3* continues to use the fan stator case mounted gearbox which provides better maintenance and accessibility features.

Other CF6-80 models are~ identified which provide thrust growth. The CF6-80C2 enters the 59,000# thrust class, which\has a larger fan diameter and additional stages in the low pressure compressor and low pressure turbine. The latest model is the CF6-80E 1, very similar to the CF6-80C2 but with even higher additional thrust capability.

Engine Characteristics

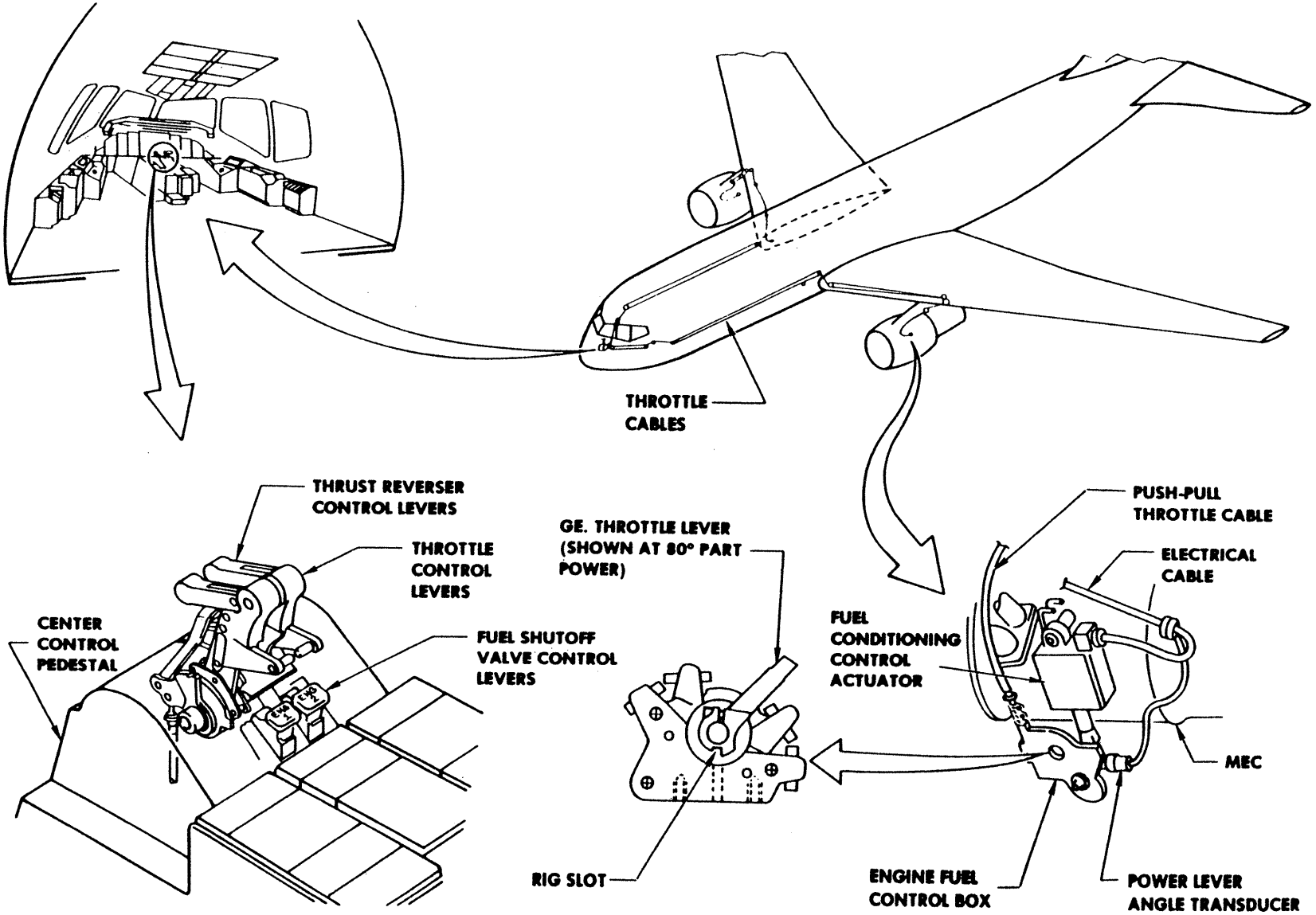
Engine Description	-80				-50		-6
	A	A2	A1	A3	C2B	E2B	D1
1. Thrust Ratings							
TO @ 92 deg F	46,930	48,670	46,990	48,970			
TO @ 79 deg F					53,200	53,200	
To @ 84 deg F							40,300
MCT @ 77 deg F	43,660	45,720	43,610	45,800	46,300	46,300	37,500
2. Max EGT							
TO (5 min)	940 C	940 C	940 C	940 C	945 C	945 C	910 C
MCT	895 C	895 C	895 C	895 C	910 C	910 C	880 C
Start (40 sec)	870 C	870 C	870 C	870 C	900 C	900 C	900 C
(max)	750 C	750 C	750 C	750 C	960 C (-2 min accel)	960 C (-2 min accel)	925 C (-2 min accel)
3. Weight Basic Engine (incl opt equip)	8825 lb	8825 lb	9205 lb (incl fan rev, cowling, exh nozzle & centerbody)	9205 lb	8946 lb	9017 lb	8015 lb
4. Dimensions							
Height (max envel)	95.07 in	95.07 in	105.6 in	105.6 in	105 in	105 in	105 in
Width (max envel)	97.89 in	97.89 in	94.5 in	94.5 in	94.0 in	94.0 in	94.0 in
length	166.92 in (fan spinner to TRF)	166.92 in	235.6 in (fan spinner to centerbody)	235.6 in	183.0 in (fan spinner to TRF)	183.0 in	188.0 in (fan spinner to TRF)
CG location (sta)	223.0 in	223.0 in	221.5 in	221.5 in	224.3 in	224.3 in	227.0 in
WL location	98.5 in	98.5 in	97.5 in	97.5 in	96.9 in	96.9 in	98.1 in

Power Management Philosophy

The single most important component of the engine systems is the Main Engine Control (MEC) which regulates fuel flow to the combustor and controls the compressor variable geometry. The other components of the power management system work through or support the MEC functions. Engine thrust is controlled from the cockpit by two systems. The fuel shutoff system is a two condition system on, off. Both aircraft types provide a lighted electrical switch for each engine on the center pedestal below the throttle levers. The electrical circuit energizes a motor which drives the MEC fuel shutoff le full open or full closed, thus providing or blocking fuel flow discharge from the MEC The MEC fuel shutoff lever is closed at 0 °-5 ° and full open at 40 ° -45° of travel.

The throttle system is used to control speeds above idle, and forward or reverse mode of the fan reverser. From the throttle levers for each engine in the cockpit center pedestal, there is a system of switches, interlocks, pulley drums, flexible cables and pushrods to the MEC power levers on the engines. There is a close angular relationship between the mechanical movement of the cockpit throttle levers and the MEC power levers. In addition there is an electrical analog system of throttle position sensed by the engine mounted Power Management Control unit (PMC) through a resolver installed to the throttle mechanism in the cockpit. The thrust reverse lever , pivoted on the throttle, controls the thrust reverser mode and engine speed command the thrust reverse mode.

Power Management Philosophy

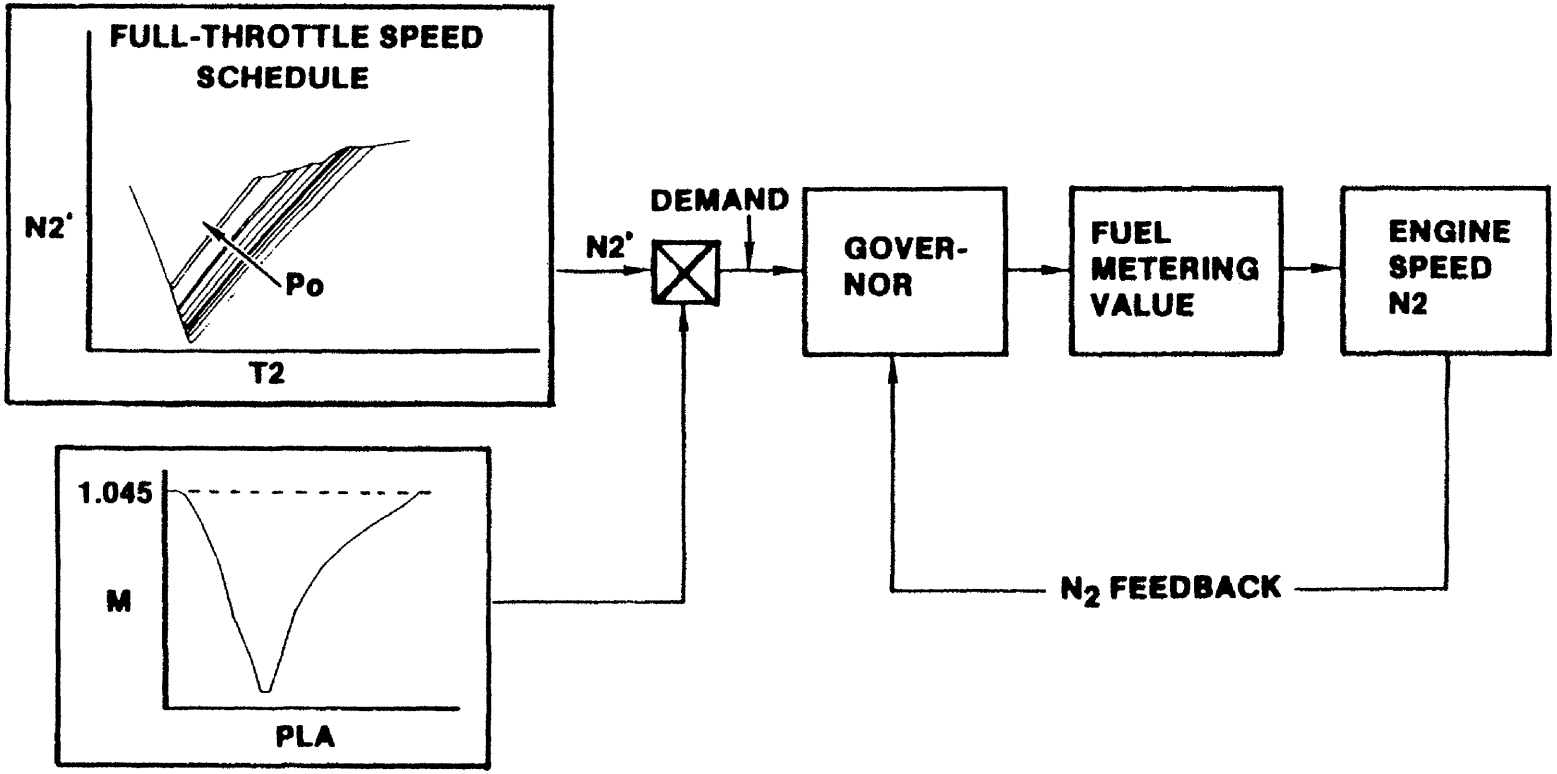


N2 Speed Governing

The CF6-80 MEC uses a corrected N2 speed governing system, whereas the previous MEC's were physical N2 speed governing controls. Corrected N2 speed is determined by a calculation that adjusts existing ambient conditions to standard day base. The calculation used in the MEC factors in the thrust desired (Power Lever Angle, PLA) and modifies that demand by factors of ambient pressure (Poc) and inlet air temperature (T2) to produce a speed required for the core rotor (governor) to move the required amount of air that provides the thrust.

A given mass flow of air thru the engine should produce the same thrust day after day, component deterioration being eliminated. All factors that affect air mass flow are not included in the calculation, for example humidity and condensation are omitted, so the results are not perfect, but close. It provides a significant improvement in the relationship of throttle position versus thrust.

N2 Speed Governing

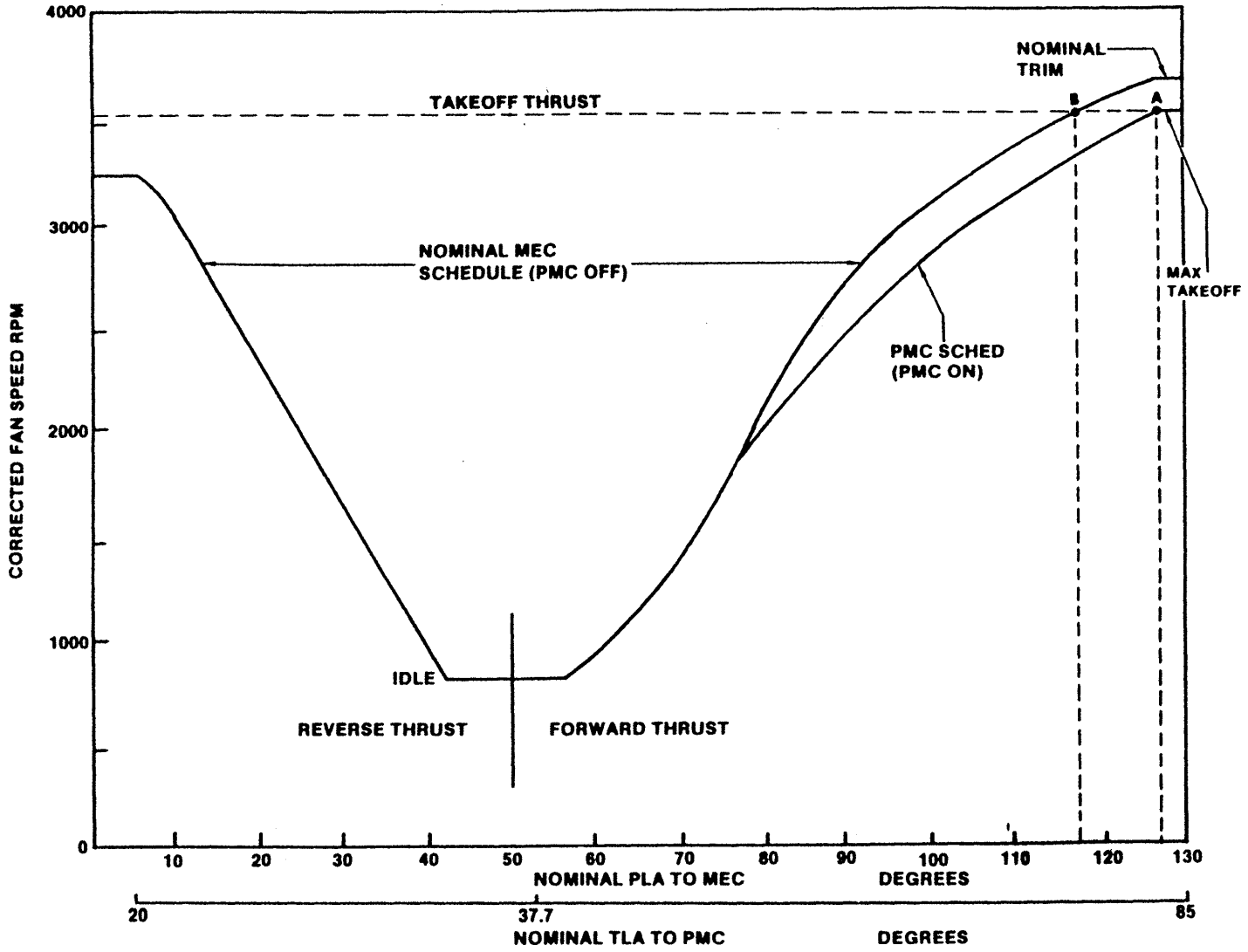


PMC Interface

The Power Management Control (PMC) is designed to sense throttle position and display on the N1 indicator the predicted N1 resulting from that N2 speed, given correct G2, P ambient, and Mach number for calculations. It regulates a direct current power supply to control a MEC speed trim mechanism that adjusts N2 speed as required to keep N1 on the target value the PMC is set for. Aircraft sensors, computers and cockpit displays are integrated with the PMC to achieve this capability.

The PMC schedule is developed as an offshoot of the MEC power lever schedule. The nominal forward MEC schedule (PMC-OFF) shows the engine will develop T .0. N1 rpm at a PLA of 118^0 (point B). However, if the PMC is ON, the PMC will have down trimmed the MEC so much that the throttle will have to be advanced until the MEC PLA is at 127^0 (point A) before the N1 rpm is at T.O. speed. Notice the PMC schedule is lower than, or downward, from the MEC schedule. The range of authority of the PMC speed trim is the space between the two lines, hence the PMC is considered to have only down trim authority. The reverse mode MEC schedule is below the PMC schedule. Because of the mechanism in the MEC, the PMC speed trim cannot exceed the MEC schedule; therefore the PMC is "blocked out" of influence in thrust reverse operation.

PLA vs. MEC Schedule



Thrust Output

The operation of the engine is managed by the operator to avoid exceeding the limits established by the terms of the sale and the warranties and guarantees provided by the manufacturer. The thrust output of the engine is one of the terms identified. Included figure shows a typical requirement for N1 in order to develop a specified level of thrust. Notice the effect of ambient temperature on the N1 speed required. At *"A"* {colder) less N1 speed produces the same level of thrust as at B {warmer). This is true up to the hot day condition C, which is a temperature identified in the sale terms. Above the hot day temperature the engine becomes EGT {Exhaust Gas Temperature) limited in operation rather than a "flat rated" thrust engine. It is termed a "flat rated" engine because of the visual characteristic of the thrust curve below the hot day temperature. Above the hot day condition, the thrust obtained from the engine decreases sharply because the core section of the engine, being at its EGT operating limit, cannot operate at higher speeds to drive the fan to higher speeds. The data provided in such figures is available in the flight manuals and programmed into the thrust control computers of the aircraft.

N1 speed has been selected as the thrust setting parameter. It is not the only parameter that can provide this function. Engine pressure ratio (EPR) is acceptable, and N2, fuel flow and EGT combined have some value.

The arguments for N1 include:

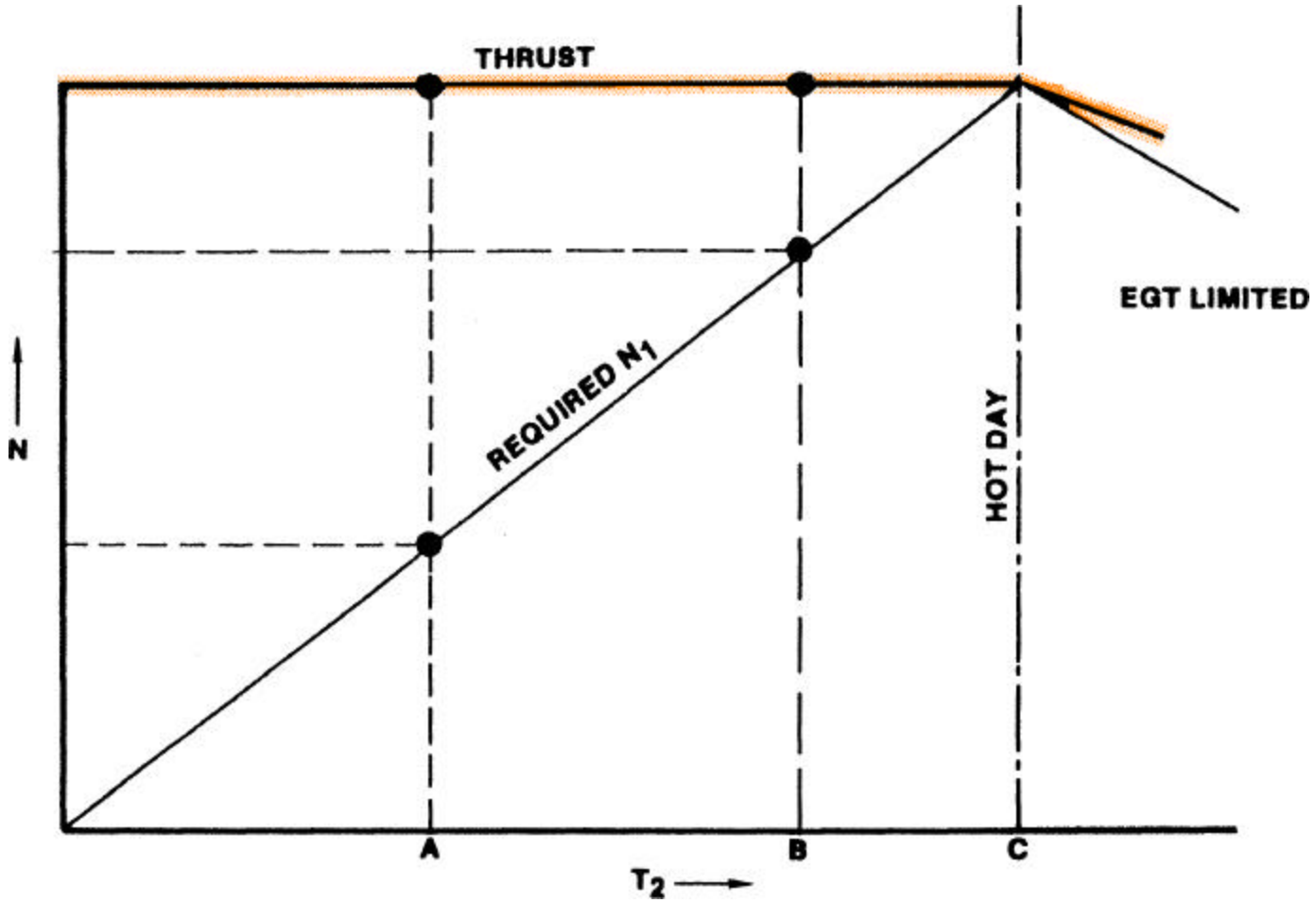
1). Simple, reliable, maintainable indicating system.

2). Deterioration in modules other than the fan result in increases in fuel flow and EGT producing increases in the core thrust component of total thrust.

3). The fan module is easy to observe visually to assure no deterioration in performance capability.

4). With a PMC system (Power Management Control) there is a consistent relationship between throttle position and thrust.

N1 Speed For Rated Thrust

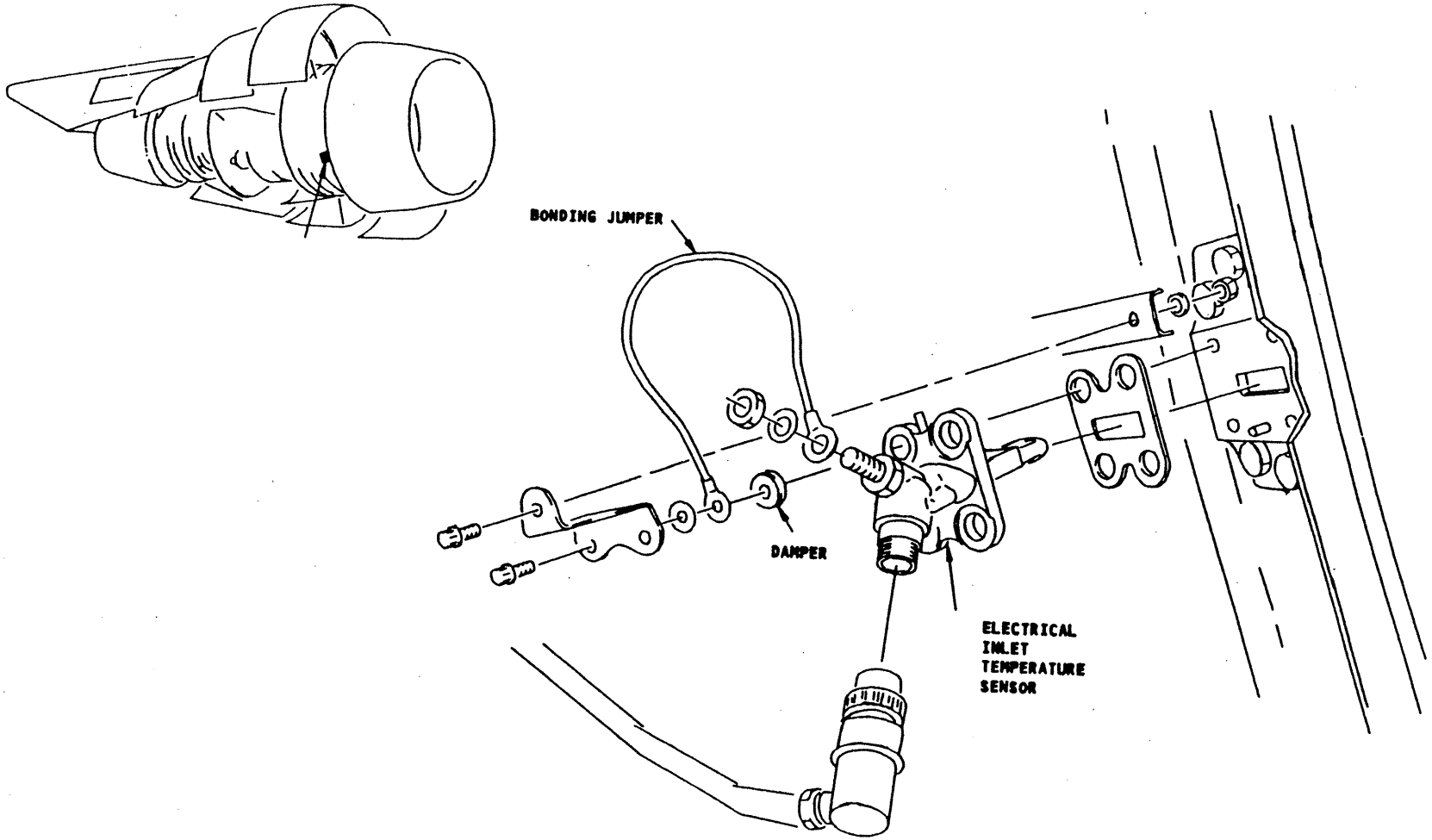


Engine Sensors - T1.2 Sensor

TheT1.2 sensor provides an electrical signal proportional to the fan inlet air total temperature. The electrical signal is required by the power management control as a parameter in its computations. The PMC uses the T1.2 signal to compare with aircraft furnished temperature. A detected failure of the aircraft temperature signals causes the PMC to rely on the T1.2 signal for computation of required N1.

The sensor is installed in the fan stator case forward of the fan containment at 4:30 o'clock (all). The sensor employs a platinum resistance element wound on a ceramic core energized from the power management control. A constant current (12 1/2 ma), 10v DC maximum power circuit supplied by the PMC is influenced by the temperature of the inlet air on the platinum resistance element. The variation of resistance changes the circuit voltage directly with temperature, typically 1 1/2 -3 1/2 VDC.

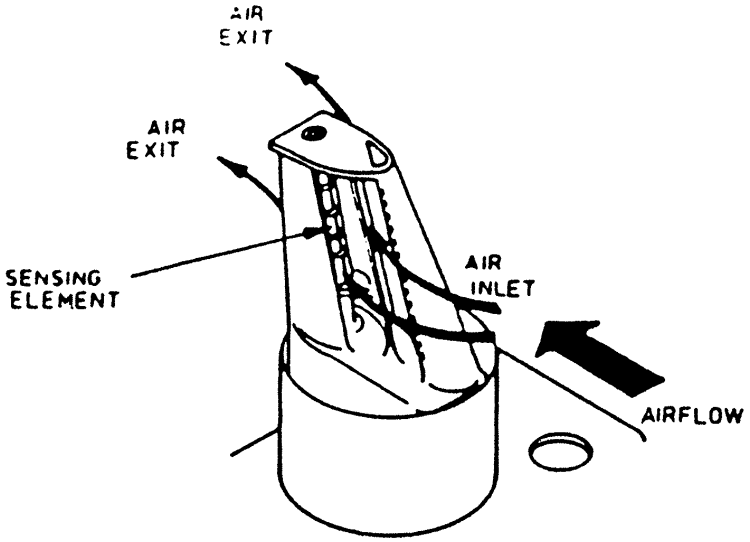
Engine Sensors - T1.2 Sensor

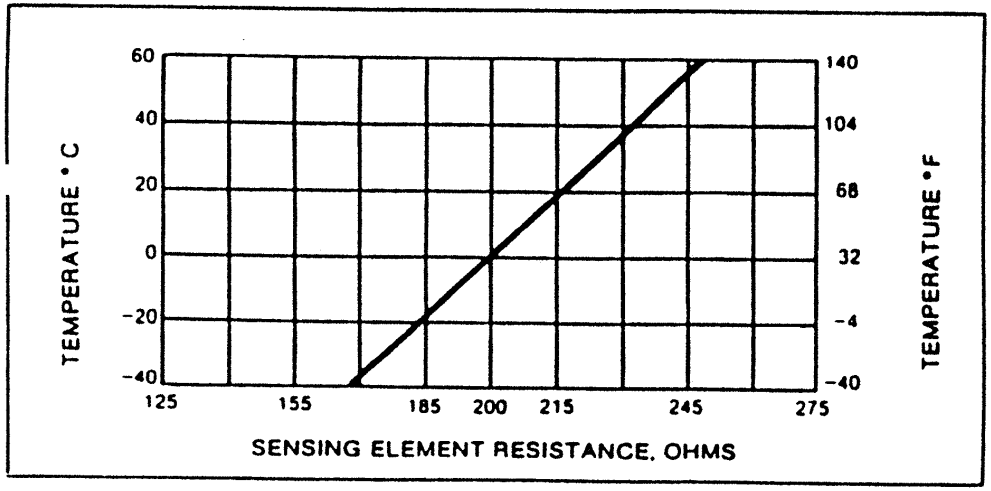


Electrical T1.2 Sensor

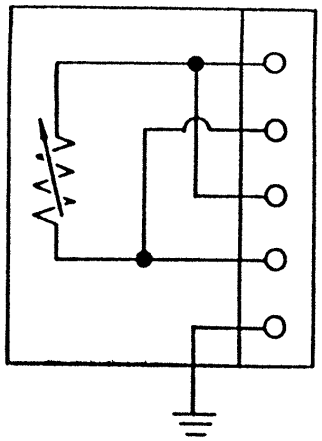
The probe is protected by being placed in a trailing position of a hollow vane and a second vane in the wake of the first. The device is approximately 2" W X 1 1/2" L X 5" H and weights about 1 pound. There is a four hole rectangular mounting plate for bolting to the forward fan case thru isolation pads. A five pin electrical connector is used providing a redundant circuit capability.

Electrical T1.2 Sensor





TEMPERATURE-RESISTANCE GRAPH

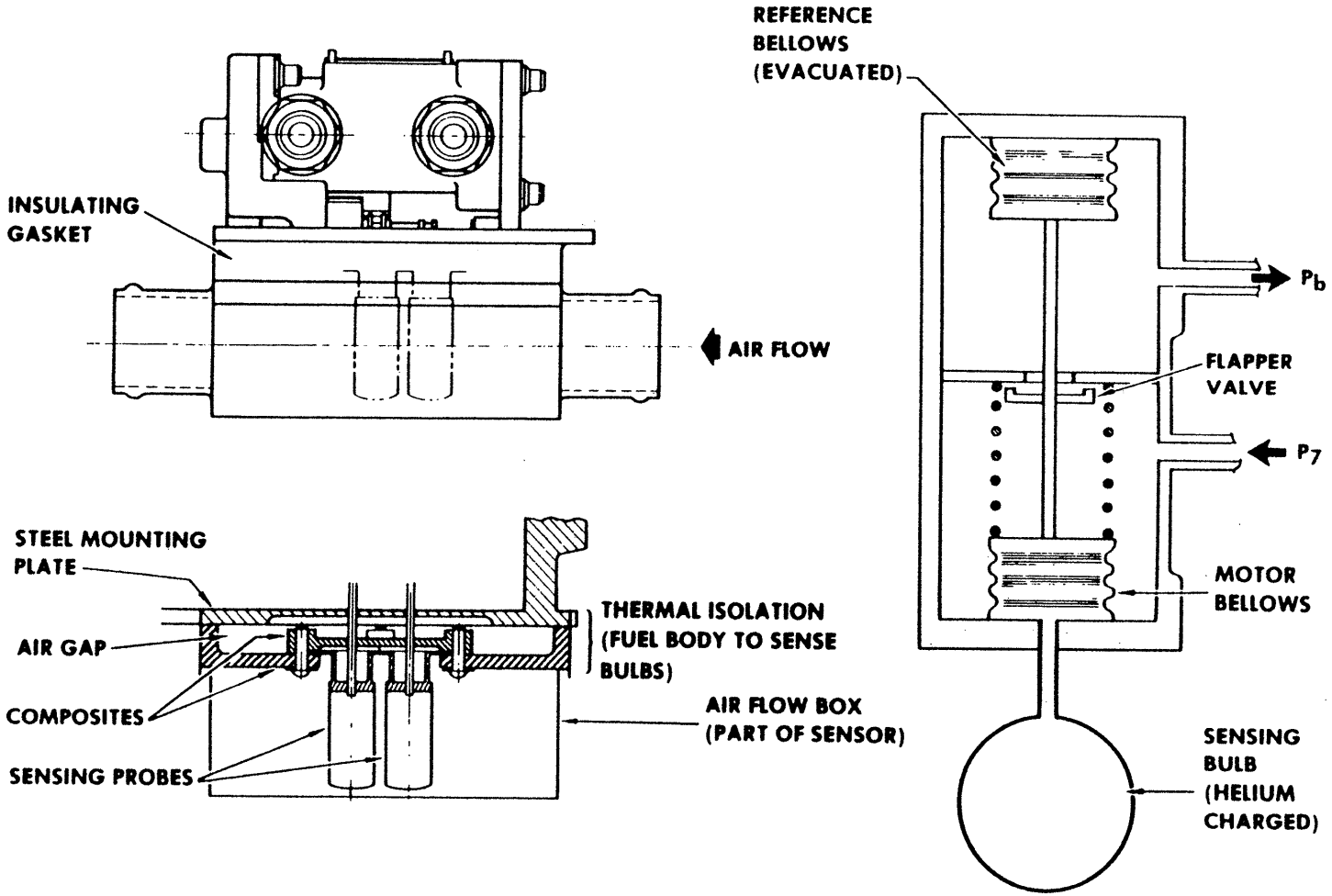


SCHEMATIC DIAGRAM

T2 Sensor

The sensor elements are two thin wall INCO 718 finger tubes pressurized with helium. A rectangular insulated cooling plenum surrounds and protects the sensor elements. There are tubular extensions for connection to the cooling air tubes. The inline valve body and fuel tube connections are outside the mounting flange. The sensor is approximately 4 1/2" L x 3 1/2" W x 4 " H, weighing about 2 1/2 pounds. The mounting flange has bolt holes asymmetrically located on the rectangular plate. There are two fuel tube spherical seat adapter ports on one surface labeled P7 and Pb. The fuel tubes are not shrouded. The MEC servo pressure, Pc, is used as muscle to rotationally position a 3-D cam proportional to the P7 -Pb pressure developed in the T2 sensor. The axial position of the 3-D cam is the result of an altitude sensor signal. The 3-D cam output and the power lever position cam combine to produce a corrected N2 speed requirement on the MEC fuel metering valve control governor. The CF6-80A3 sensor is installed in a similar duct on the fan stator case at 4:00 o'clock. The sensor is constructed so that only the two tubular probes extend into the duct.

T2 Hydromechanical Sensor



Compressor Inlet Temperature (CIT) Sensor

This device provides a fuel pressure signal proportional to the temperature of the high pressure compressor inlet air (CIT or T25). The hydromechanical fuel control unit uses this pressure to compute corrected acceleration fuel flow and compressor airflow control system requirements.

The sensor is installed in the fan frame at 4:30 o'clock (ALF) and attached by its flange to the frame.

Construction Features
The portion of the sensor in the airstream is a coiled tube pressurized with helium, The sensor element is protected by an outer sheet metal covering and by metal rings welded to the outer covering to protect the coiled tube fore and aft from ice impact and shedding vibration frequencies.

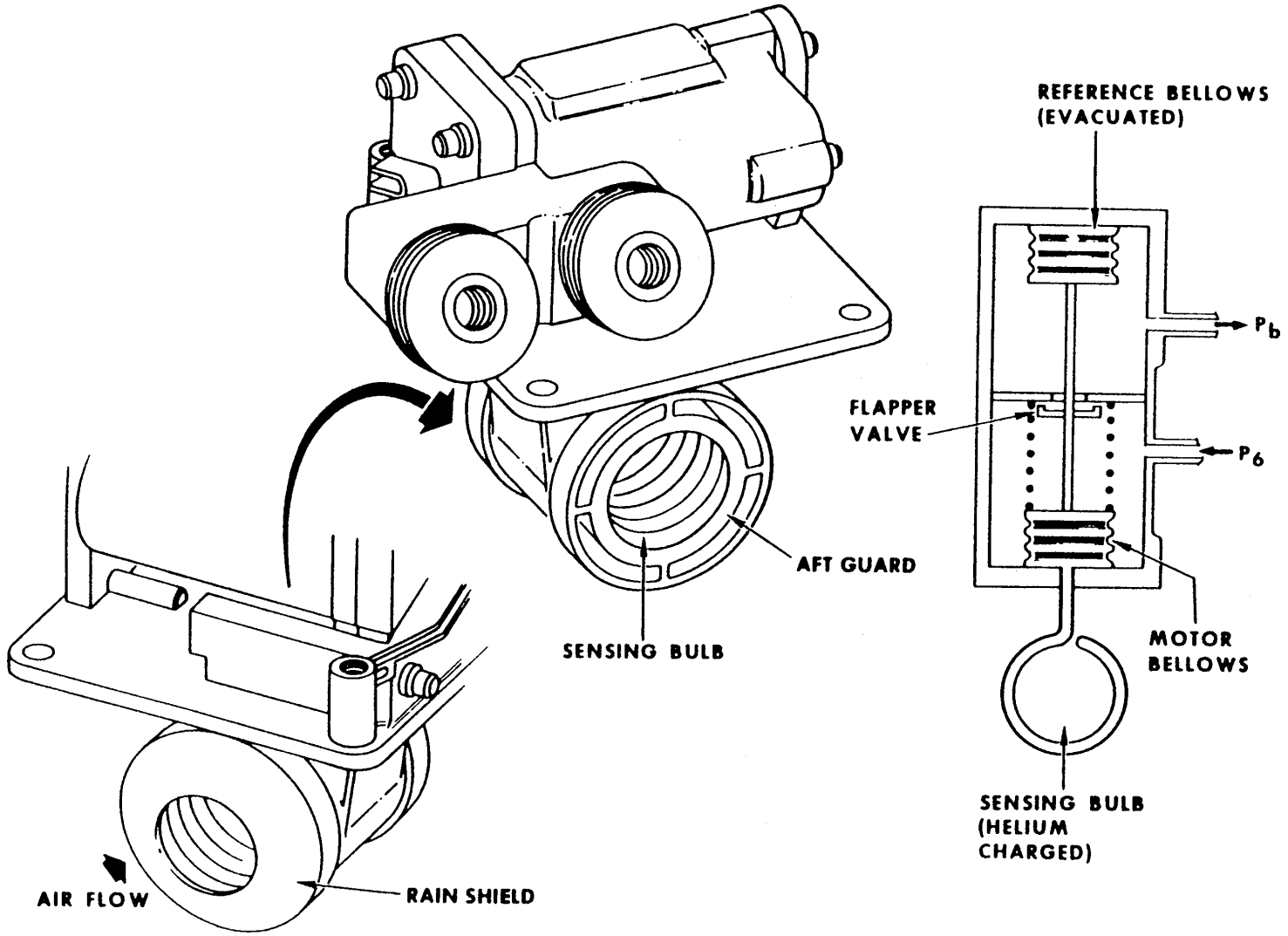
A rain shield is installed at the air flow inlet side of the sensing element. It is a conical section of sheet metal. It prevents direct water impingement onto the sensing bulb and the subsequent temperature error induced by evaporative cooling.

Within the engine compartment are the fuel signal pressure servo supply (P6), return (Pb) shrouded "B" nut connections and the inline regulator valve body.

The sensor is approximately 41/2" L x 4' W x 5" H. It provides a square mounting flange. Its shape assures one way installation to provide proper airflow through the coiled tube. The two fuel line connections are by shrouded fuel tube couplings. The ports provide P6 and Pb couplings for lines going to the MEC P6 and Pb ports.

The inline regulator valve (Flapper) is controlled by the effects of air temperature on a confined volume of gas. An aneroid (Motor Bellows) connected to the sensing coil reacts against a coil spring and a vacuum chamber (Reference Bellows) to position a variable orifice. Cold air reduces the aneroid pressure opening the variable orifice permitting the fuel supply pressure (P6) to drop proportionately. The force balance is established at the flapper valve. Very little actual valve area changes are necessary to develop the pressure changes necessary.

CIT Sensor


REFERENCE BELLOWS
(EVACUATED)
P_b
FLAPPER
VALVE
P_6
AFT GUARD
SENSING BULB
MOTOR
BELLOWS
SENSING BULB
(HELIUM
CHARGED)
AIR FLOW
RAIN SHIELD

Electrical N1 Fan Speed Sensor

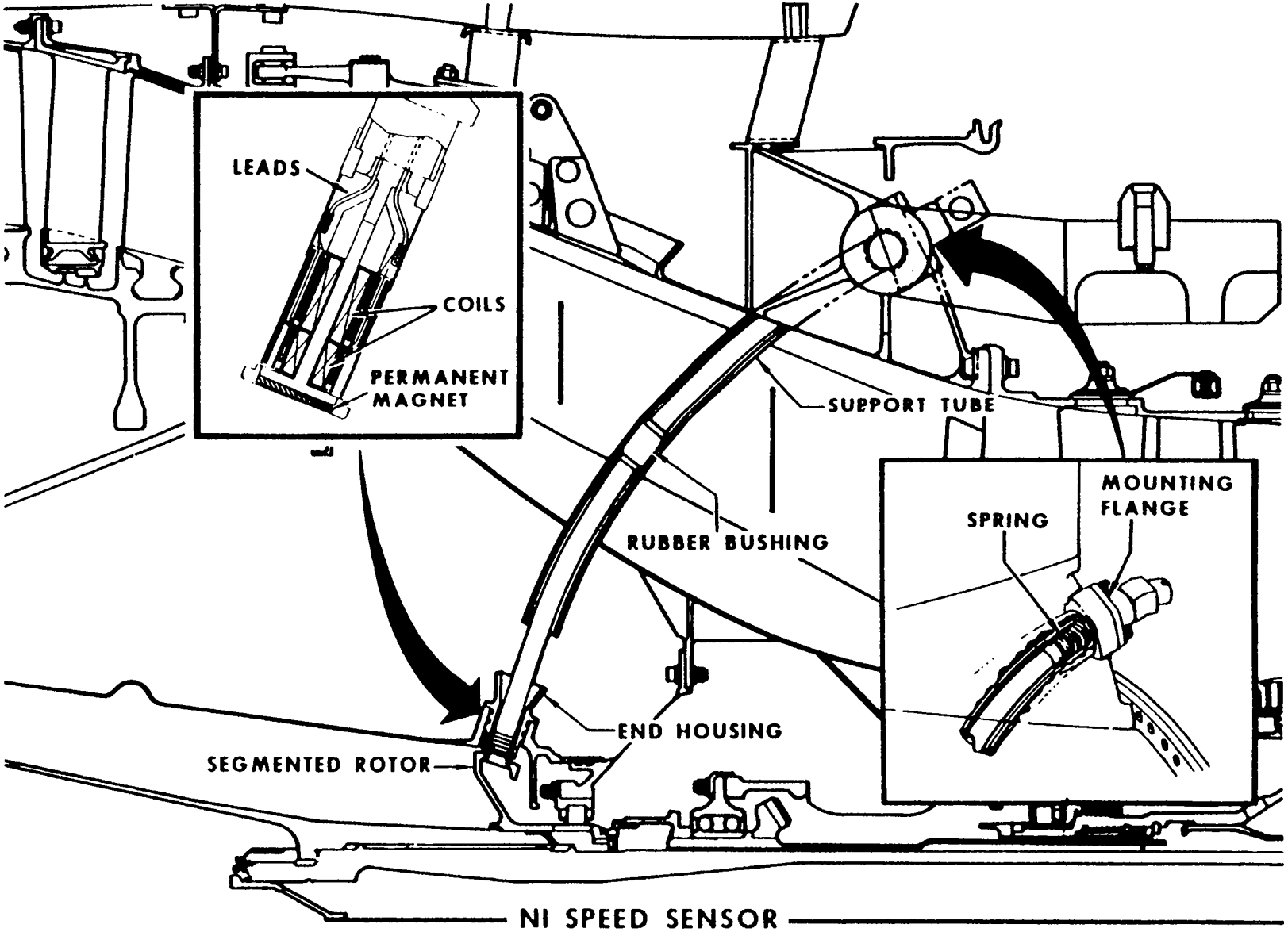
The N1 sensor serves three functions: N1 speed indication to cockpit indicator, speed input to Power Management Control (PMC), a 1/rev signal for fan trim balance. The N1 speed sensor produces two signals. One goes to the N1 indicator for actual speed. The other is compared with the N1 command signal in the PMC. If a difference is noted, a torque motor drive signal will adjust the MEC down trim mechanism changing N2 speed, to make the actual speed agree with the command N1 . An N2 speed change will have a direct effect on the N1 speed.

The sensor is installed into the "A" sump pressure sleeve through strut #3. It extends to a point close to a 38 tooth rotor cage at the #2 bearing inner race assembly. The magnetic tip is protected from sump oil by a titanium receiver in the fan frame pressure sleeve. The assembly provides a Viton bushing for support midway along the lead, a spring loaded flanged mounting adapter, and an electrical connector. The spring loaded mounting assembly provides from 25-80 pounds axial force to keep the magnetic tip seated into its titanium receiver.

The sensor tip contains a permanent wafer magnet and two coils in tandem. The coils are part of separate circuits, one dedicated to the PMC and one for cockpit indication. The chromel leads are insulated by magnesium oxide swaged within the stainless steel tubular housing. The N1 analog signal to the N1 indicator is routed through the PMC, but remains electrically isolated. The other circuit provides a fan speed input to the PMC. This signal is processed into digital words for use in the PMC and transmission over the data bus for the N1 indicator digital display.

The device is self energized. It produces an electro-magnetic pulse whenever the magnetic field at the tip is disturbed by the passing teeth of the rotor cage on the fan shaft forward of the No.2 bearing inner race. The rotor cage has one of the 38 teeth modified to pass closer to the sensor producing a stronger signal. It enables a vibration analyzer to detect a I/rev signal used in rotor trim balance.

Electrical N1 Fan Speed Sensor

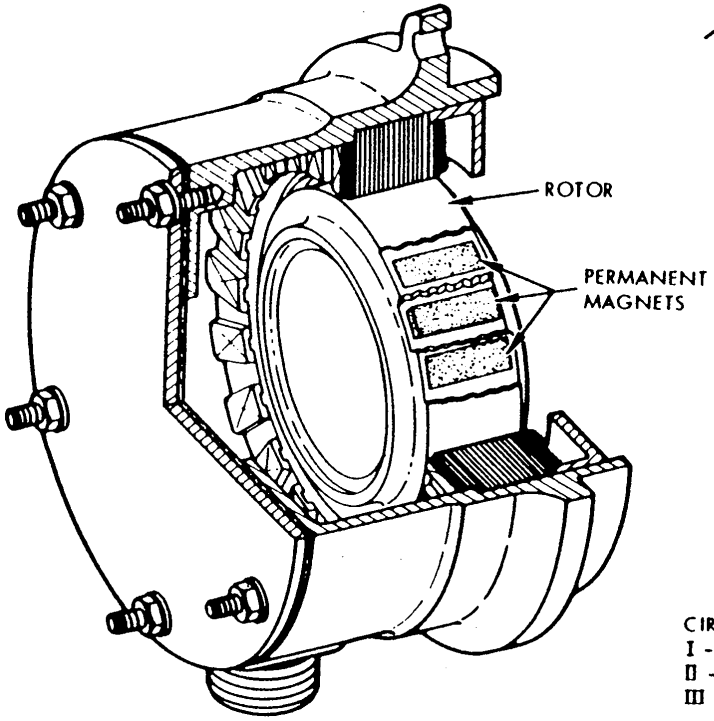


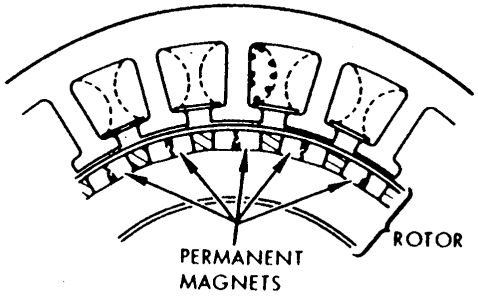
Control Alternator

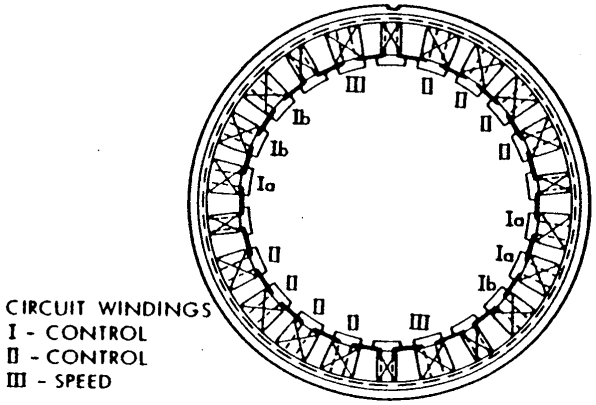
The alternator is installed on the transfer gearbox pad opposite the horizontal drive shaft. The rotor will turn at 9397 RPM at 100% core speed.

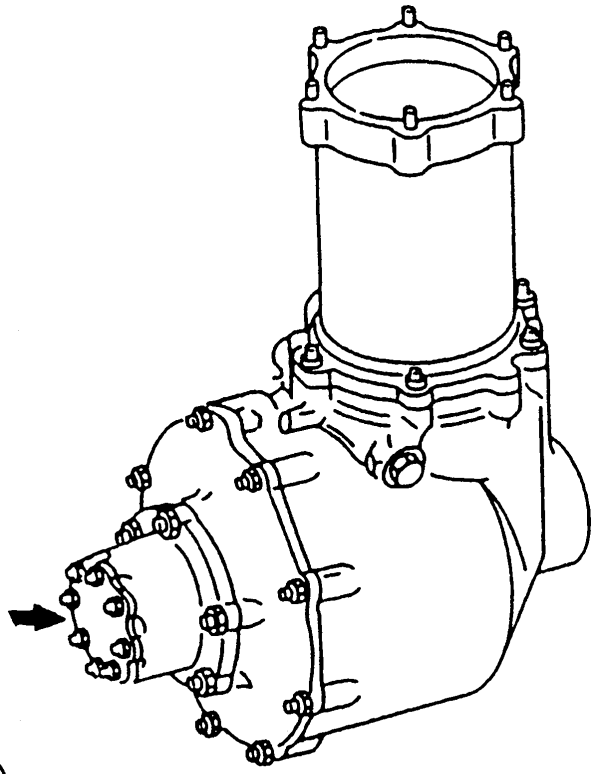
The stator provides twenty two poles. The pole windings are separately part of the three circuits: speed indicating, and two power circuits for the PMC. One ten pin connector gives access for the service cable. The stators are interchangeable. An access cover plate on the aft surface must be removed to install a core engine motoring device for borescope inspection. The motoring device will bolt to the stator housing and the drive shaft will fit into the TGB spacer square drive. The rotor is attached to the TGB horizontal drive shaft and keyed. The rotor contains twenty two permanent magnets with the N and 8 poles alternating. The spacing is the same as the stator poles. The rotors are interchangeable. The power circuit produces 210 volts max. open circuit voltage, 3.5 amps max short circuit current and the frequency ranges from 775 Hz at 45% N2 to 1895 Hz at 110% N2. The speed signal produces 50 volts max. open circuit voltage, 5.4 amp. max. short circuit amperage at frequency ranges between 51.7 Hz at 3% N2 to 1895 Hz at 110% N2.

Control Alternator









Exhaust Gas Temperature (EGT) Probes

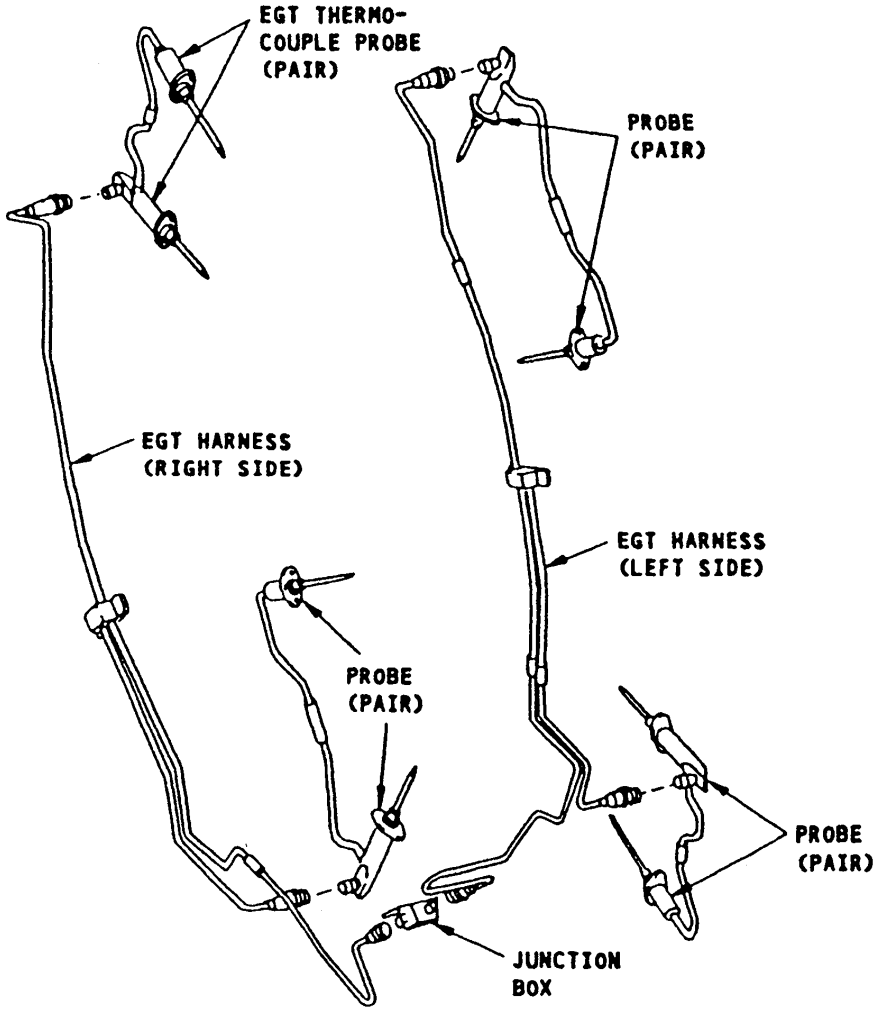
The EGT indicating subsystem provides a cockpit display of the engine primary airflow temperature at engine station 4.9, inlet to the LPT. The indicating system gages permit the operator to monitor the condition of the engine for that parameter, and initiate corrective action, if necessary. There are eight chromel-alumel thermocouple probes installed into bosses of the LPT forward case. This location is station 4.9 and is just ahead of LPT stage 1 nozzle and aft of the HPT stage 2 rotor .

There are two configurations of EGT harnesses and probes.

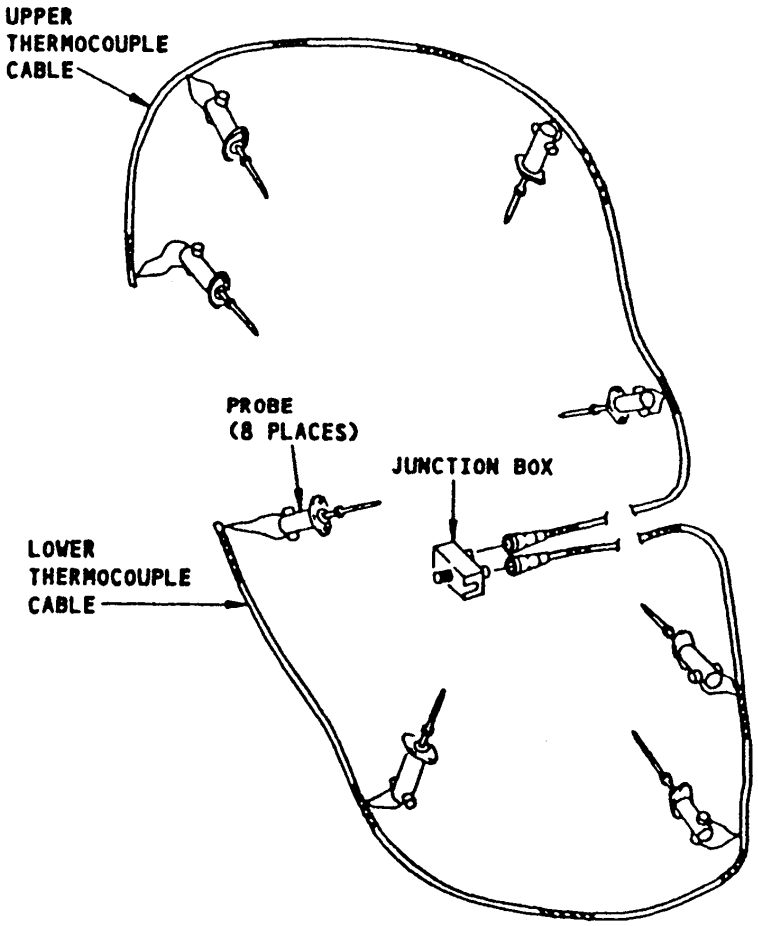
The rigid type thermocouple harness contains four paired probe sections, each probe containing two thermocouples, each section providing a 4 pin connector. There is a left hand and right hand averaging harness interconnecting sections 1 thru 4 to the junction box. There is a third connector on the junction box for the forward lead connection to the aircraft interface. Each probe of a harness pair contains two chromel-alumel junctions making a total of 16 junctions. The junctions are encased in a swaged stainless housing using Magnesium Oxide (MgO) as the insulation. Each probe has two immersion depths within a protective sleeve. The sleeve is drilled so there is a positive circulation of gasses around the probe.

The flexible type thermocouple harness contains an upper and lower averaging harness, with each harness connecting to eight individual thermocouple probes. Each probe contains two chromel-alumel junctions making a total of 16 junctions. The upper and lower harnesses individually connect to a single junction/shunt box mounted on the left side of the engine. From the junction/shunt box is a single aircraft interface connector. Through the shunt portion of the junction box, the output signal is reduced by 35 deg.C to the aircraft indicator.

EGT Sensing System



RIGID LEADS

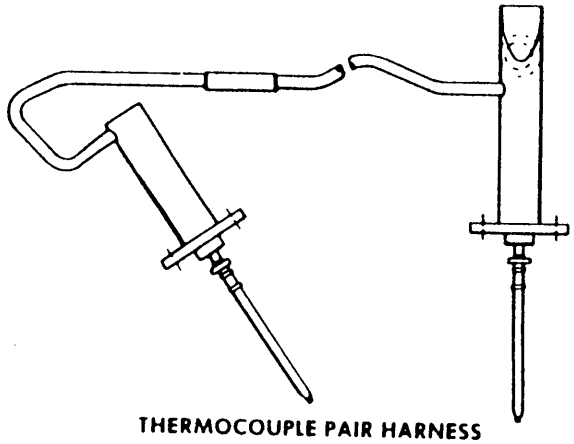


FLEXIBLE LEADS

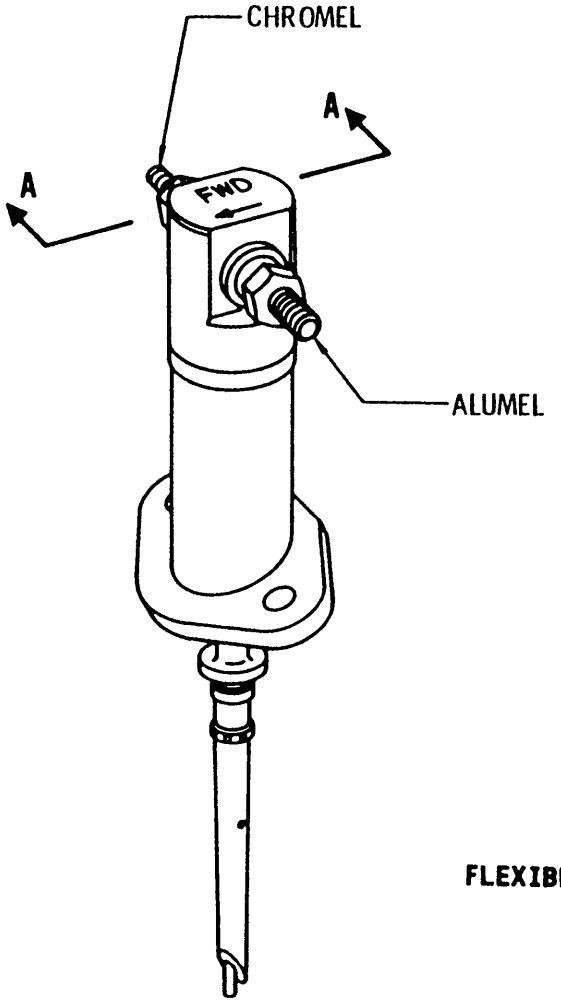
Thermocouple Probe

The thermocouple probes for either application are identical in operation. Hot gasses circulate about the probes heating the junction of dissimilar metals (chromel and alumel) causing a voltage potential to develop. A circuit is formed in the indicating system when the other ends of the leads are joined (the cold junction) at the indicator. The indicator moves up scale with increased gas temperatures, a function of the increased potential as gas temperatures increase. Malfunctions of the system affect the indicating ability as well as the averaging ability. Short circuits and open or high resistance connections prevent indications. Sometimes new junctions are formed by shorts which alter the balance of the circuits and influence the average temperature indication either higher or lower depending on the location of the new junction.

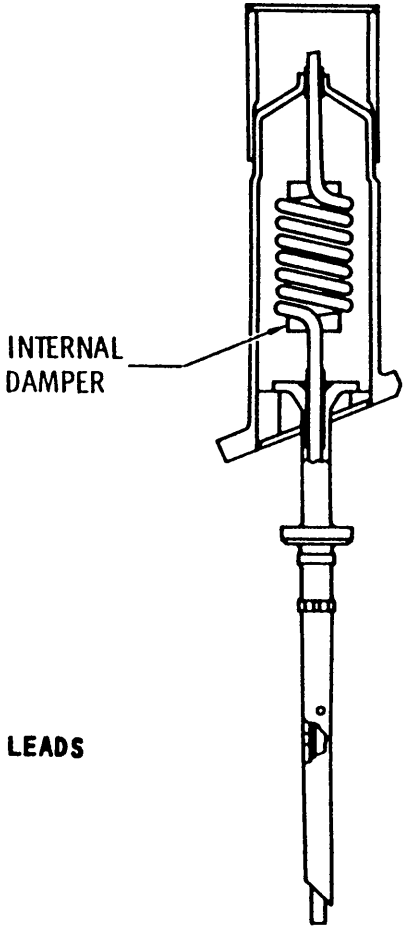
Thermocouple Probe



RIGID LEADS



FLEXIBLE LEADS



SECTION A-A

The fuel pump contains an integral centrifugal boost element and a high pressure positive displacement gear element. An external fuel/oil heat exchanger is located between the high pressure element and the fuel filter to provide fuel heating and oil cooling functions continuously. The fuel filter for the engine provides filtration protection for the MEC and the fuel servo system including the stator and bleed valve actuators, CIT sensor, hydromechanical T2 sensor, fuel flow meter and IDGS oil/fuel heat exchanger (both customer furnished), and fuel nozzles.

A filter relief valve permits continuous flow to the MEC in the case of clogging. The relief valve cracks open when the pressure drop in the filter reaches 35 +/- 5 psid. This relief valve is fully open when pressure drops to 45 psid.

A servo fuel heater provides preheat to the servo fuel of the MEC to prevent the formation of ice within the MEC sensor servo valves. It is not required on the -80Al/A3 engine.

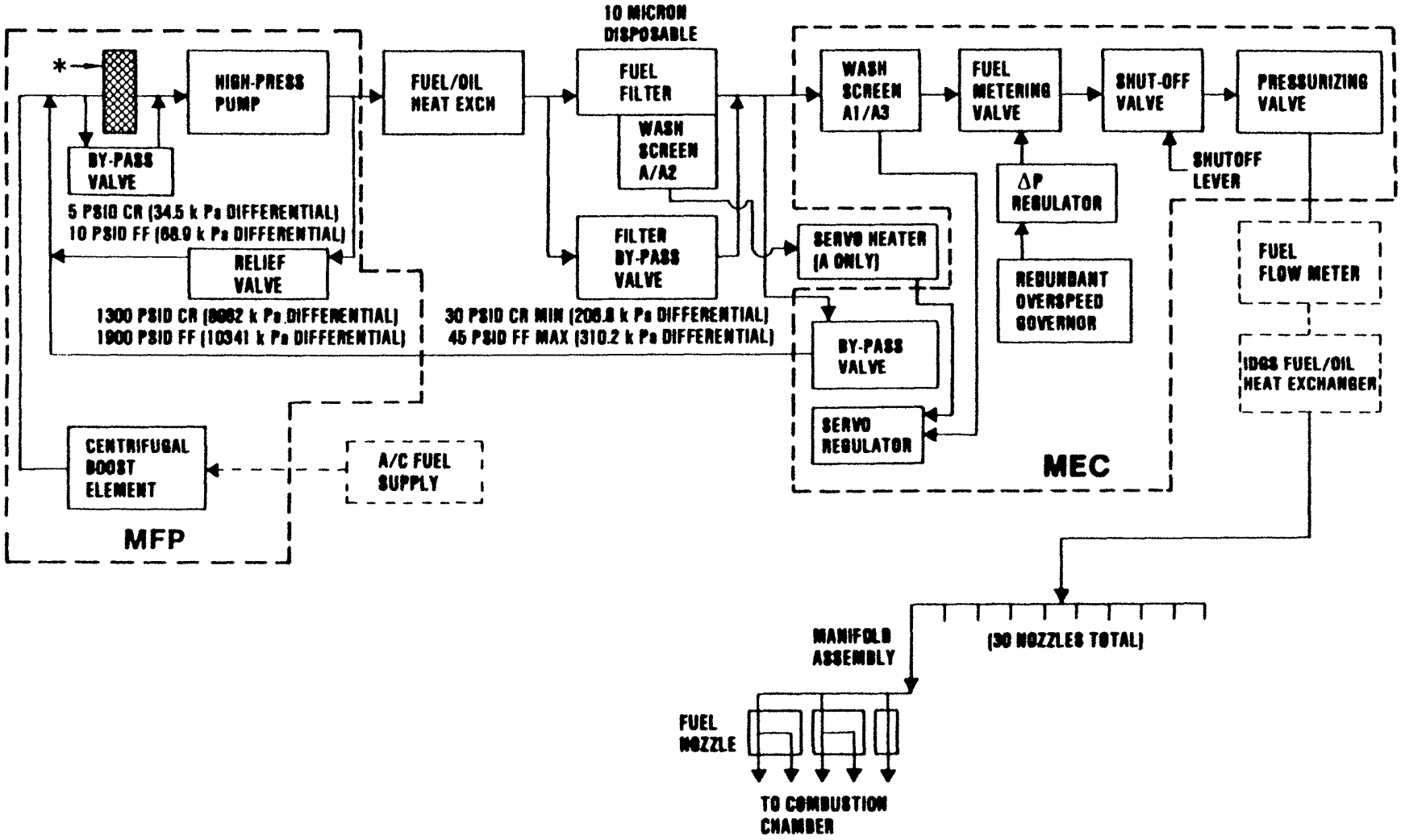
A pressurizing valve in the MEC maintains minimum system pressure.

The 30 fuel nozzles are grouped in ten clusters of three each. They are of two types: twenty- one have primary and secondary while nine have secondary flow only. Check valves in the fuel nozzles prevent back flow on shutdown.

Type of Fuel

The engine will operate satisfactorily when using fuels conforming to, alternately, or in any combination: MIL-T-5624K Grade JP-4 or JP-5; MIL-T-83133 Grady JP-8; ASTM D 1655, JET A, A-l and B, and approved fuel conforming to the General Electric Specification D50TF2.

Fuel System Schematic



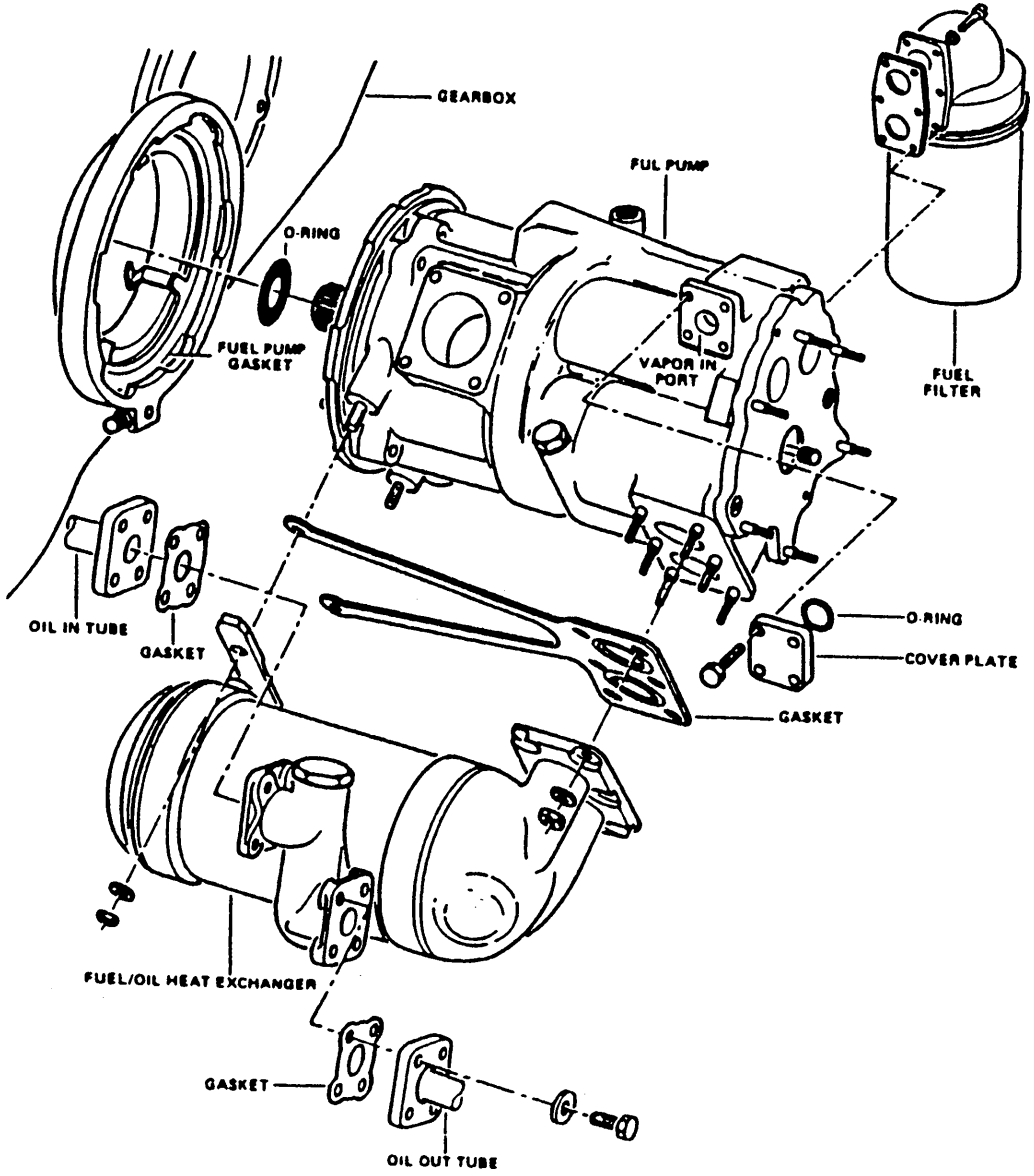
Main Fuel Pump

The pump produces the fuel flow required to produce the thrust level selected by the operator. The pump receives fuel from the aircraft supply at relatively low boost pressures. The pump provides additional boost from its internal centrifugal stage to supercharge its high pressure pump element to prevent cavitation. The -80A3 pump is like the CF6-50 pump. It is installed on the 7 o'clock pad on the aft of the fan mounted AGB. Attachment is by a QAD ring to the gearbox. Alignment pins assure correct positioning.

The pump is driven by the AGB thru a splined shaft turning a centrifugal impeller, a gear pump, and the MEC drive spline. The drive shaft spline is lubricated by engine oil from a jet in the lube pump delivering oil into the common gearshaft. There is a groove for an "0" ring just aft of the spline, and a metal bracket seal ring completes the drain cavity by making a seal at the mounting flange. The drive shaft, as it enters the pump, employs an impregnated babbit type of seal. Therefore, seal failures might allow oil or fuel to drain from this AGB drain port. The other parts of the pump and drive shaft are all fuel lubricated. This fact given rise to the requirement that any time the engine is motored there must be a positive fuel pump pressure provided by the aircraft boost pumps.

Fuel flow thru the pump begins at the fuel inlet port where the connection to the fuel supply is made. The fuel enters directly into the center of the centrifugal element and is discharged thru the scroll at an increased pressure. The pressure increase depends upon the engine speed. Ground Idle provides approximately 40 psi increase, flight idle 50 psi, and takeoff rpm approximately 60 psi. The maximum pressure increase above aircraft boost is in the region of 80 psi at the extremes of rpm and temperature. The cockpit indication of Fuel Pressure is from a tap in the Boost discharge into the jet eductors. The gage reads both the tank boost pump pressures and the MFP boost pressures .

Fuel Pump, Heat Exchanger and Fuel Filter



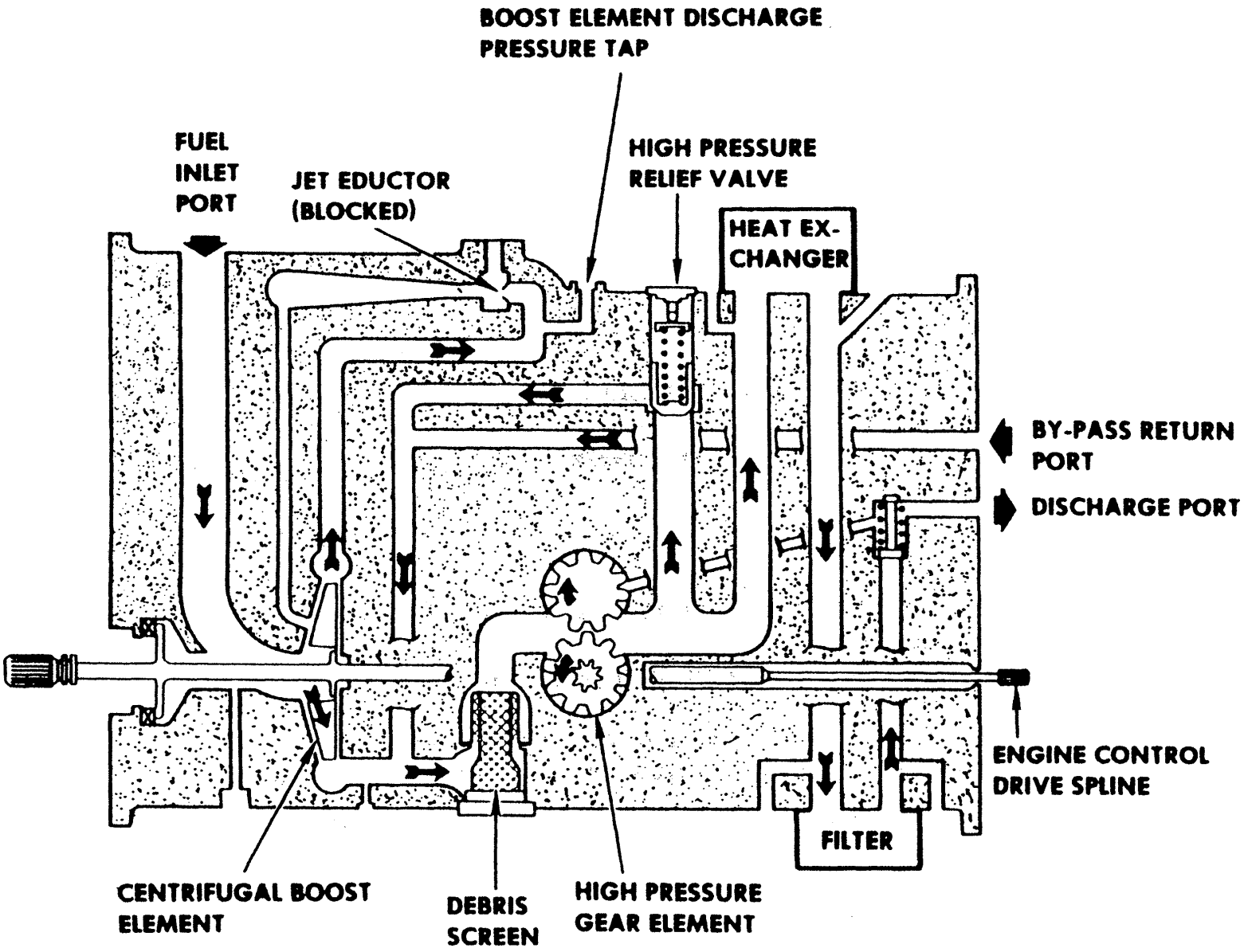
The centrifugal discharge flow is used to power two parallel jet eductors to remove and pressurize fuel vapors that may collect in pylon vapor traps, thus preventing vapor lock in the aircraft fuel lines and providing takeoff power capability without aircraft boost pump operation. Any combined fuel and vapor re-enter the centrifugal element at mid stage and is forced to the inlet of the gear element. The vapor inlet port may be capped on some models of A310 aircraft.

The high pressure gear element inlet flow is filtered thru the Debris screen. The screen has a 520 micron value. It will protect the gear element from large particles and chunks generated upstream, but will bypass when clogging creates a 5-10 psi pressure drop. This cartridge screen should be inspected and cleaned periodically, as there is no bypass indication.

The positive displacement gear pump provides fuel quantity and pressures in excess of requirements at all operating conditions assuring a bypass flow. The pressure is limited only by the High Pressure Relief valve which opens at 1350 psid., full open by 1600 psid. The fuel is dumped to the gear pump inlet to recirculate, limiting the pressure. The MEC establishes the discharge pressure level by regulating the bypass fuel flow recirculating into the pump.

There are temperature and pressure ports provided for instrumentation. All ports are identified by cast letters.

Fuel Pump Schematic



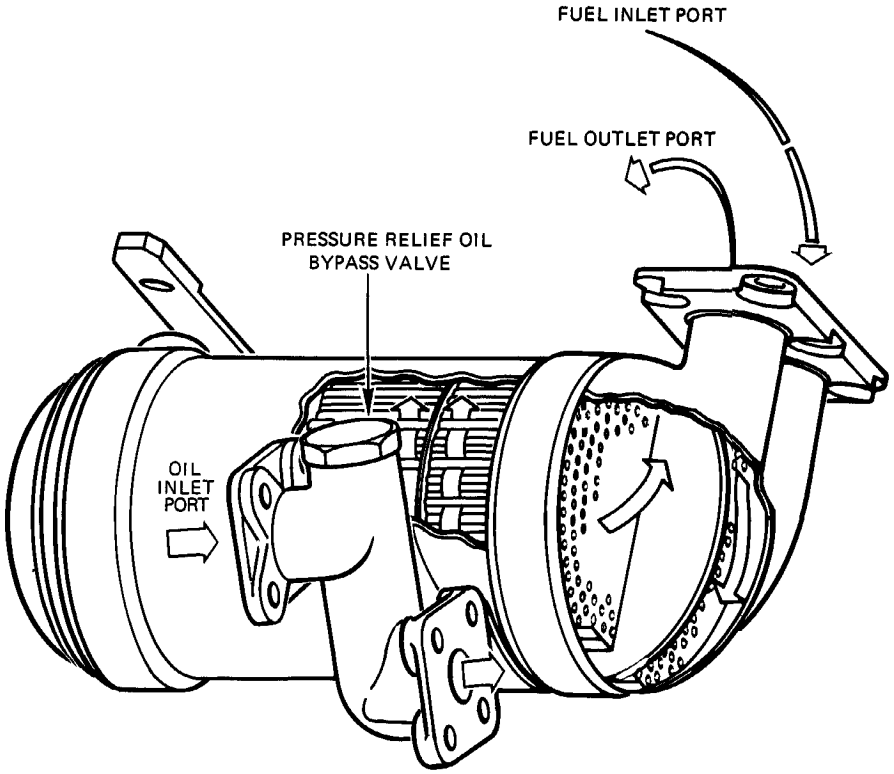
Fuel Oil Heat Exchanger

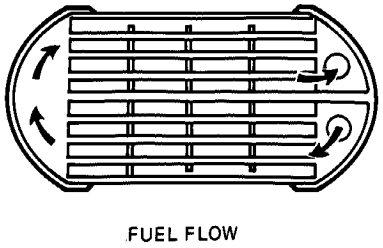
The fuel oil heat exchanger provides a single component to heat the fuel and to cool the scavenge oil by heat transfer. (Except when servo fuel heater is installed).It contains tubes and baffles to direct the flow of respective fluids. Fuel into manifold, through half of tubes to end dome, returning through remaining tubes, and exiting through the manifold. All fuel flows through heat exchanger -no bypass. Scavenge oil flows by or through a pressure relief valve before entering the exchanger.

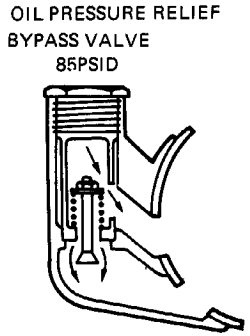
85 psid cracking, 100 psid full open.

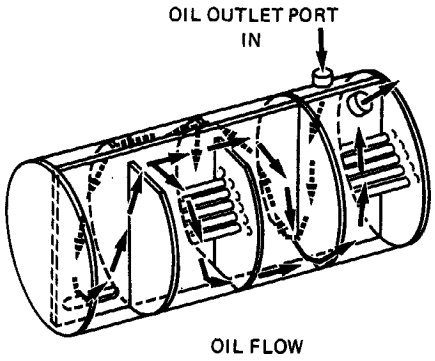
Scavenge oil makes six passes across the fuel tubes before exiting.Fuel pressures are always higher than the oil pressures.

Heat Exchanger









Fuel Filter

The fuel filter provides fuel free of contaminant particles large enough to cause Main Engine Control malfunction. It is bolted to flanged ports on right side of fuel pump (ALF). Differential pressure taps on fuel pump ports provide cockpit signal of impending filter bypass. Fuel filter clogging indicator on at 23 +/- 2 psid, off at 19.5 psid.

Filter Bypass Valve is Belvalve type. Cracks at 38 +/- psid, full open at 45 psid.

Filter element is disposable type 10 micron, may be installed either end up.

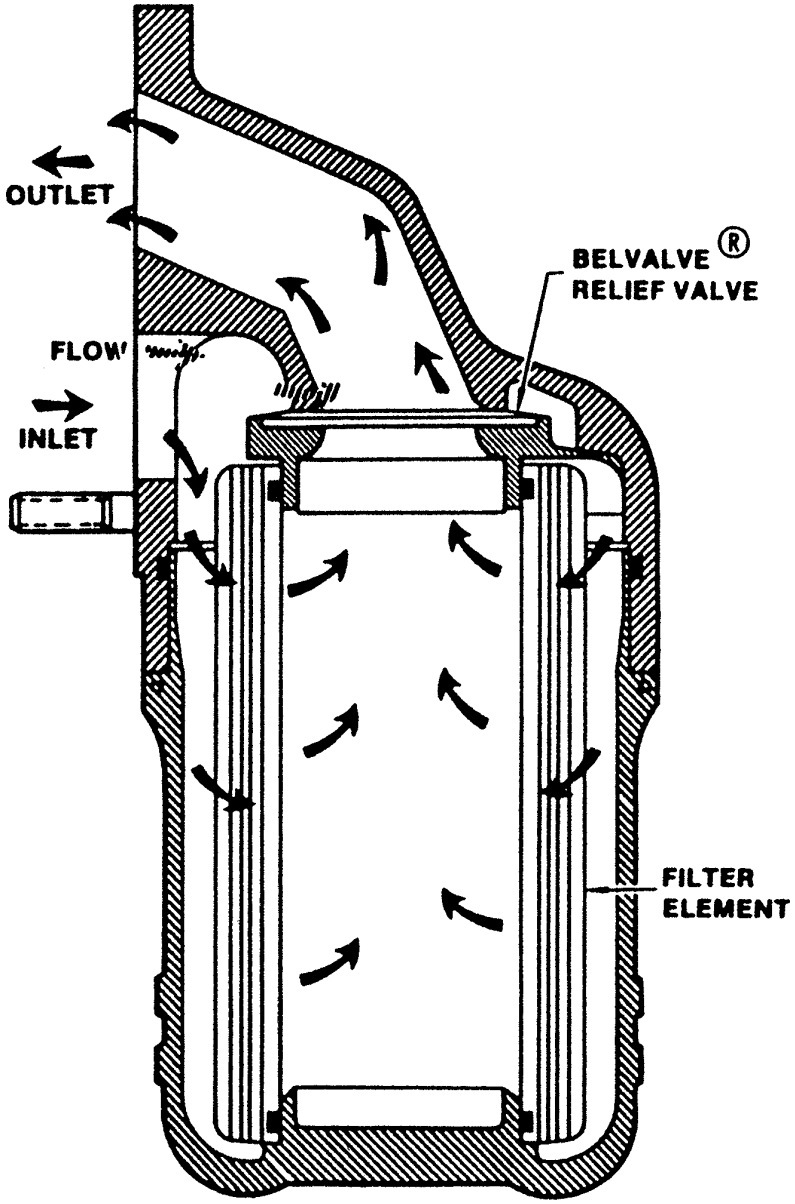
1.) Epoxy impregnated inorganic media (glass/polyester).
2.) Coarse aluminum mesh supports pleated media.

Filter bowl is installed hand tight and safety wired.

1.) Drain Plug.
2.) Seal rings each end of filter and in filter head to seal bowl.
3.) Undamaged seal ring in filter head is reusable.

Removal features on the filter bowl allows use of a strap wrench, or on some models a screwdriver shank to apply removal torque.

Fuel Filter



Main Engine Control

The MEC is installed in tandem with the main fuel pump on the aft 6:30 drive pad of the fan case mounted gearbox. While there are differences in the mounting system and the external appearance, the MEC functions are the same. The MEC is a hydromechanical computer designed to regulate fuel flow under all operating conditions, regulate Compressor airflow, and protect the engine from adverse operation. The control functions of the MEC are:

N2 fuel metering

Variable stator control

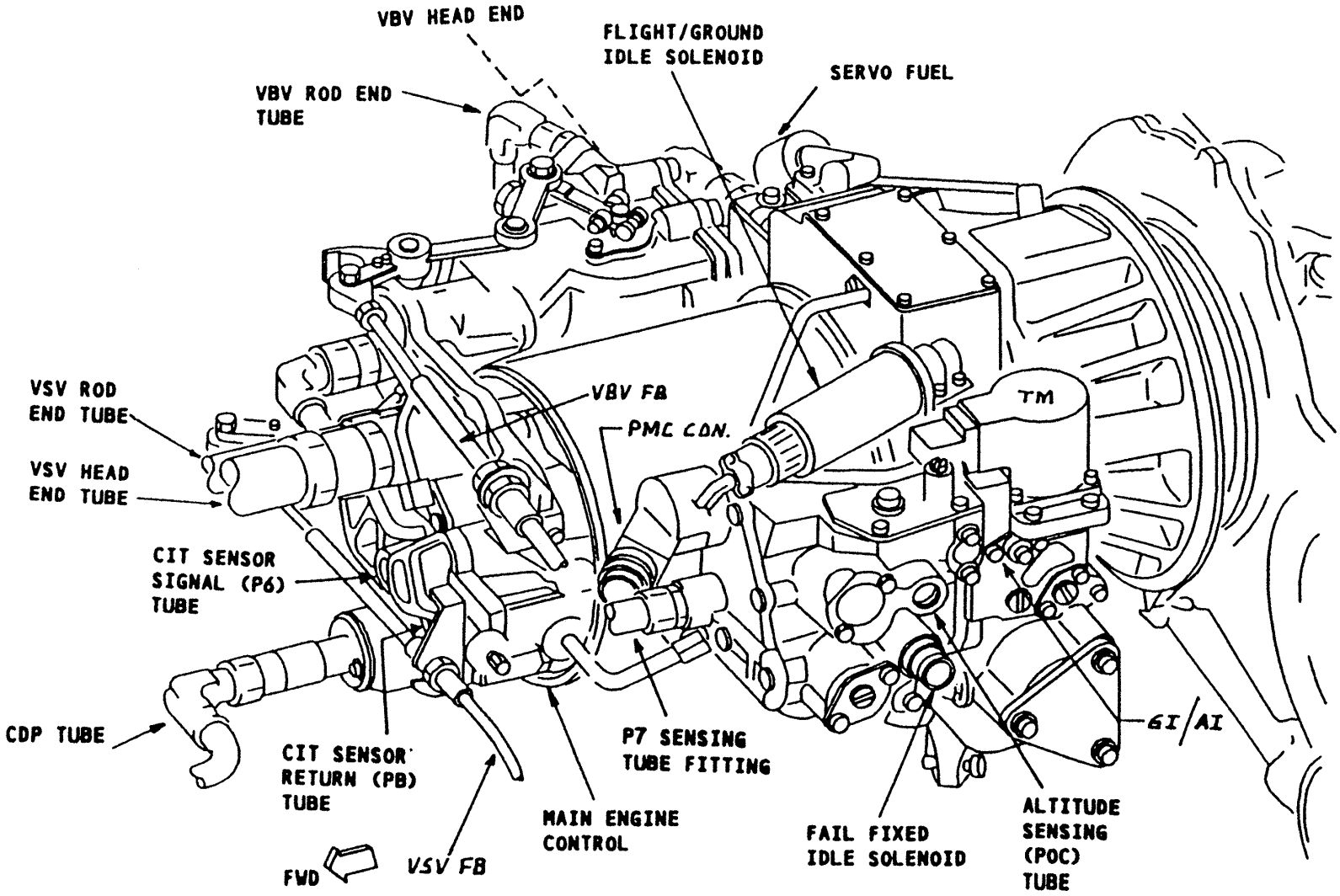
Variable bleed value control

Electrical interface with the Power Management Control (PMC) for N1 speed control

Electrical interface with aircraft for idle speed control

Electrical interface with aircraft and PMC for N1 speed control protection

Main Engine Control



Input Parameters Of The MEC

The input parameters of the MEC are:

a.) Physical core engine speed (N2)

b.) Throttle position (PLA)

c.) PMC torque motor current (TMC)

d.) Compressor inlet temperature (T2.5)

e.) Altitude Sensing (PoC)

f.) VSV feedback

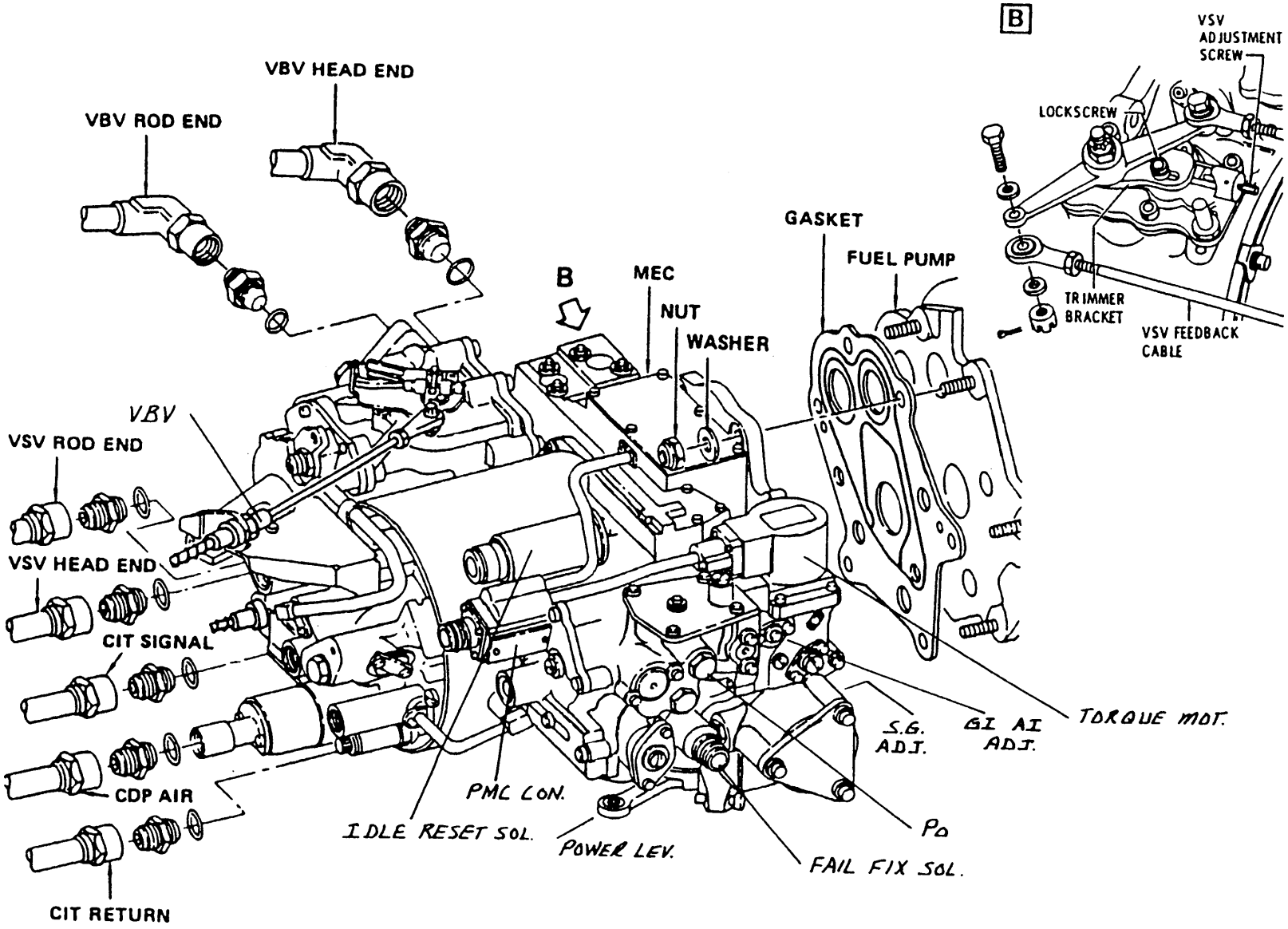
g.) VBV feedback

h.) Idle reset solenoid signal

i.) Fail fixed solenoid signal

j.) Compressor discharge pressure (CDP)

Main Engine Control



Power Lever

MEC power lever is positioned manually through the aircraft throttle system. A speed command will be applied to the isochronous governor controlling fuel flow through the fuel metering valve proportional to the PLA biased by the T2 and PoC three dimensional cam. N2 speed provides a feedback to the governor .

Reverse thrust range is 10.50 to 400 PLA (B767) and 18.20-400 (A310) 10,300 rpm to 5500 N2 rpm.

Minimum idle is 400- 570,5,500 N2 rpm. However, the A310 incorporates a modulated idle rather than minimum and approach idle selected by the idle reset solenoid. The modulated idle provides necessary compressor bleed air at minimum fuel burn on descent from altitude.

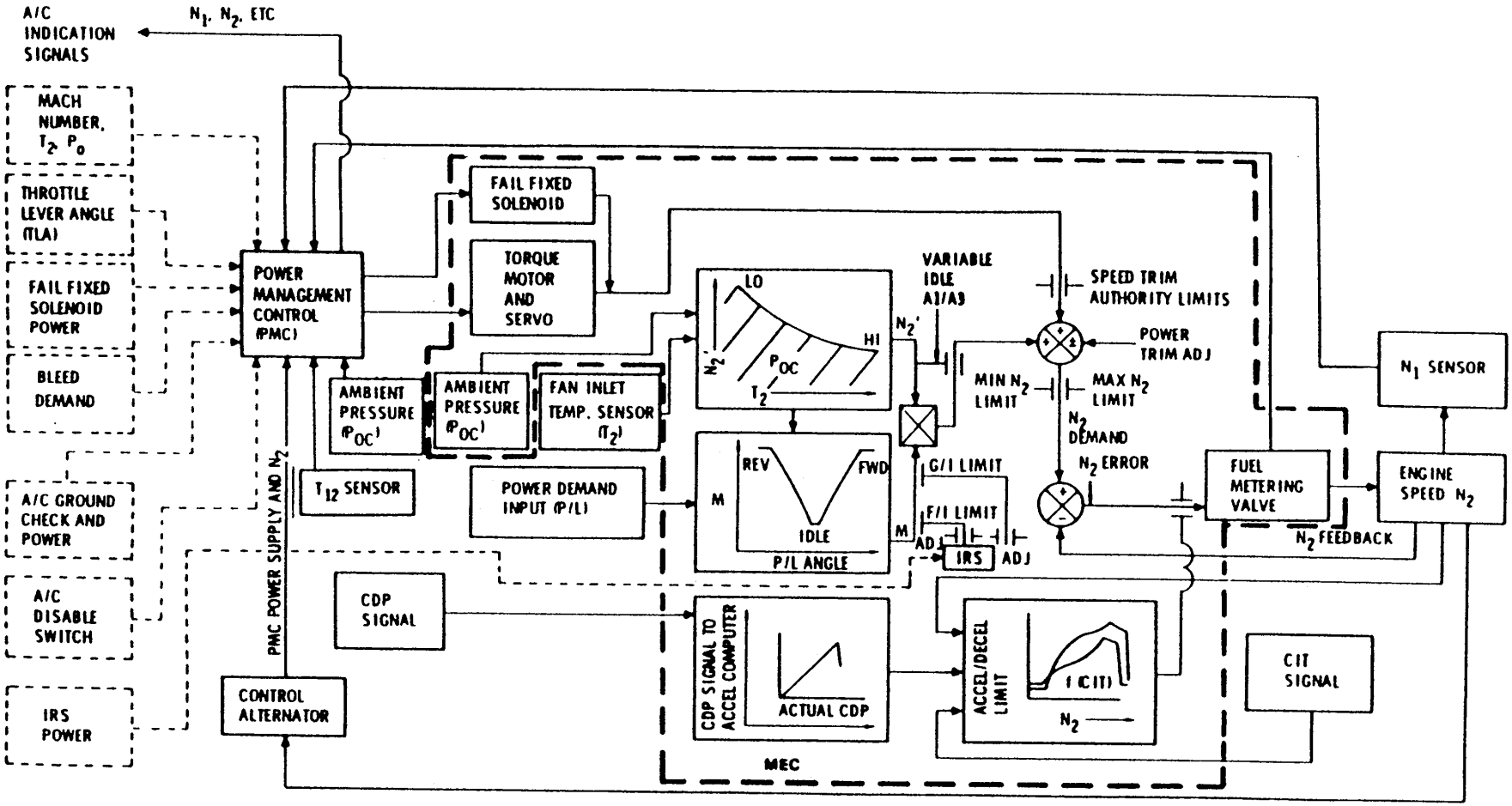
Forward thrust range is 570 to 1300 PLA, 5,500 rpm to 10,300 N2 rpm. The above under conditions of T2 = 59° and Poc is 14.7 psia.

Throttle Rig position is at 130° PLA, (Maximum forward speed command). A 80 ° PLA rig pin position is provided for aircraft rigging. A check for full throttle capability to 130° PLA is desirable following aircraft rigging.

The PMC speed trim adjustment is applied to the governor to modify the basic signal derived from the throttle position.

The slope of the power lever cam schedule and the fan inlet temperature and ambient pressure bias provide approximately constant thrust per degree of power lever angle (in PMC "disable" mode), regardless of temperature or ambient pressure. The MEC is termed a corrected core speed (N2K) control, rather than a physical core speed (N2) control as used on previous engines of the CF6 family.

N1 Speed Control Schematic

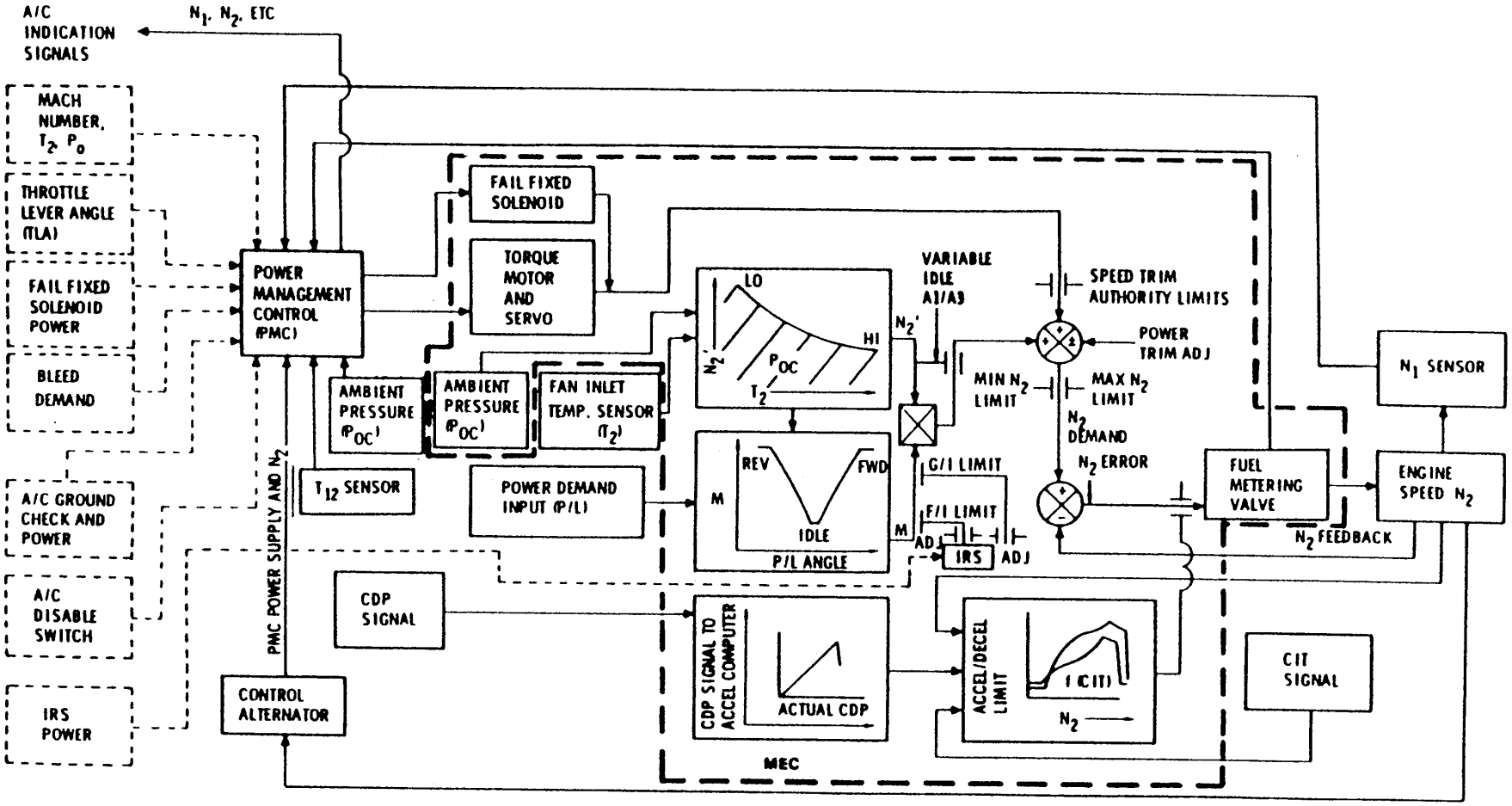


Acceleration and deceleration schedules -compressor inlet temperature (T2.5 or CIT), N2 rpm, compressor discharge pressure (Ps 3 or CDP). When the throttle is moved rapidly, the governor will attempt to position the fuel metering valve full open or full closed. Neither condition provides acceptable fuel scheduling considering the effects on the compressor airflow and the heat change on the metal of the engine. A hydromechanical computer generated schedule is provided which has authority over the governor control of the metering valve. The schedule, based upon T2.5, N2 and CDP, computes the upper and lower fuel flows desirable considering overtemperature, compressor stall line and flameout. It permits the maximum safe rate of acceleration and deceleration in response to throttle movement.

Compressor control schedules -compressor inlet temperature (T2.5 or CIT), N2 rpm, mechanical feedback of VSV and VBV position. The airflow control systems require accurate positioning to match or balance the capacities of the individual compressor stages. It has been determined through test that the measure of the stage to stage airflow is proportional to the calculated corrected N2 speed, indicated N2 times a T2.5 factor. A three dimensional cam integrates these factors to drive the servo systems of the VSV's and VBV's. The feedback cables cause the servo system pilot valves to null when the prescribed position is achieved. The schedules make possible rapid rates of compressor acceleration and deceleration.

Compressor discharge pressure (CDP or Ps3) maximum limit. It is possible that high pressures within the compressor case may cause case rupture. The CDP cam, which is part of the acceleration-deceleration computer, has a slope reversal starting at 465 psia. When higher pressures are sensed the slope reversal depresses the acceleration fuel schedule limit. The engine speed and pressure may continue to increase until the required to run fuel flow and the depressed accel limit fuel flow are the same value.

N1 Speed Control Schematic



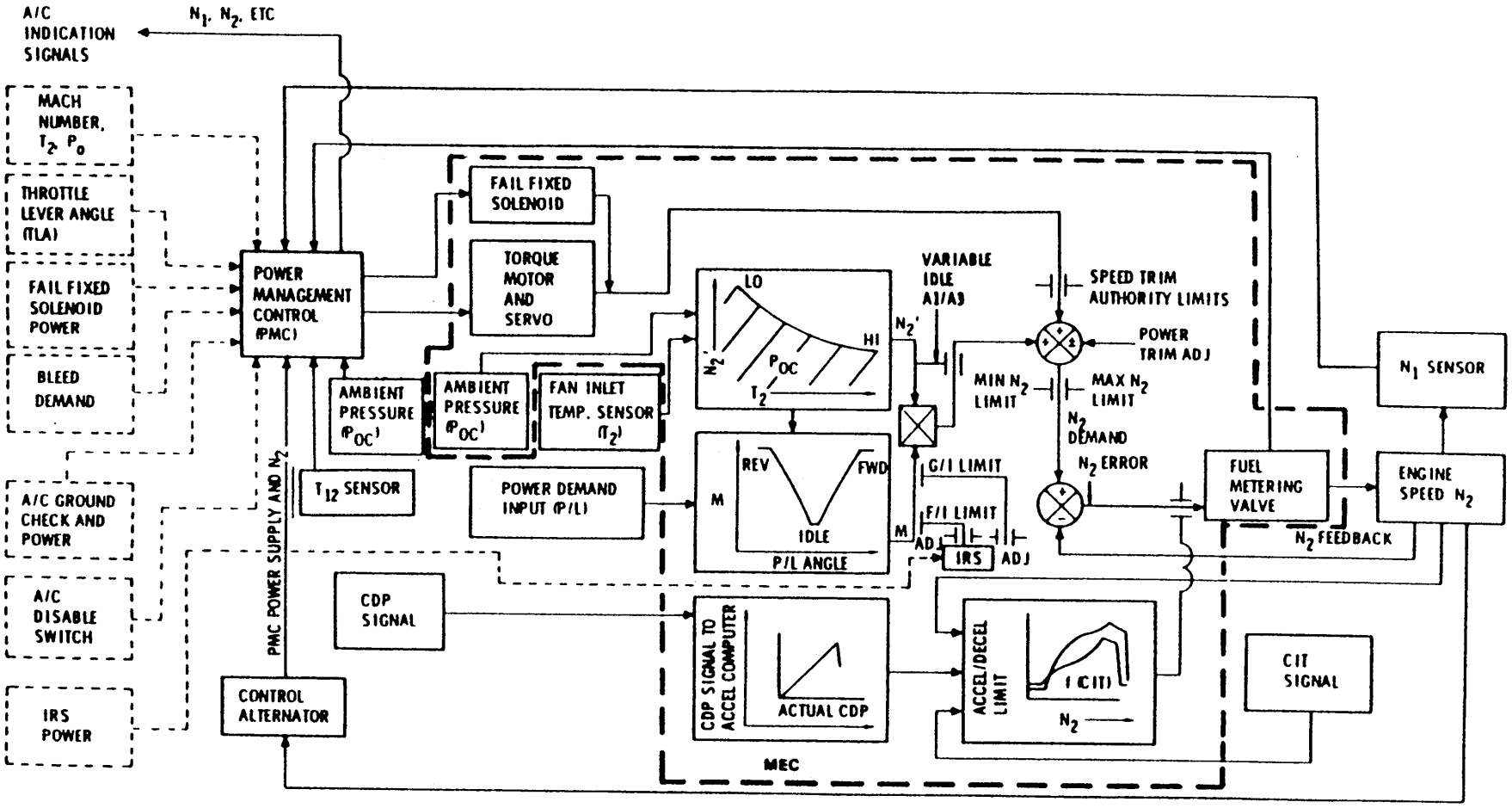
Idle Speeds

Minimum idle (range 58% -78% N2 for A310 ground and flight) -PLA, N2 rpm, ambient pressure (Poc), ambient temperature (T2), electrical 28VDC to idle reset solenoid. When the throttle is at its minimum or idle position, approximately 48° 500 PLA, the engine speed (N2) will be governed by the selection of minimum idle or approach idle. This selection is the function of the idle reset solenoid power

On the A310, whenever the weight on wheels switch is compressed, as on the ground, a switch will energize the idle reset solenoid to select minimum idle. In flight, when the TCC is in operation, Nacelle anti-Ice is off, and slats are not extended the minimum idle will be selected. This mode provides a variable idle speed as a function of Poc or altitude.

Approach idle (range A310) -PLA, N2 rpm, Poc, T2, removal of power to the idle reset solenoid. On the A310, whenever there is no weight-on-wheels, and T .C.C. is not in operation or nacelle anti-Ice is on, or if slats are extended, the engine minimum throttle position speed will be approach idle. The circuit to the idle reset solenoid will be open.

N1 Speed Control Schematic



N2 Minimum range 56.5 + 1% N2. internal speed stop screw. This is a speed calculated to maintain the Integrated Drive Generator System above its drop out speed.

N2 Maximum -range 110.0 + .4% N2. Internal speed stop screw.

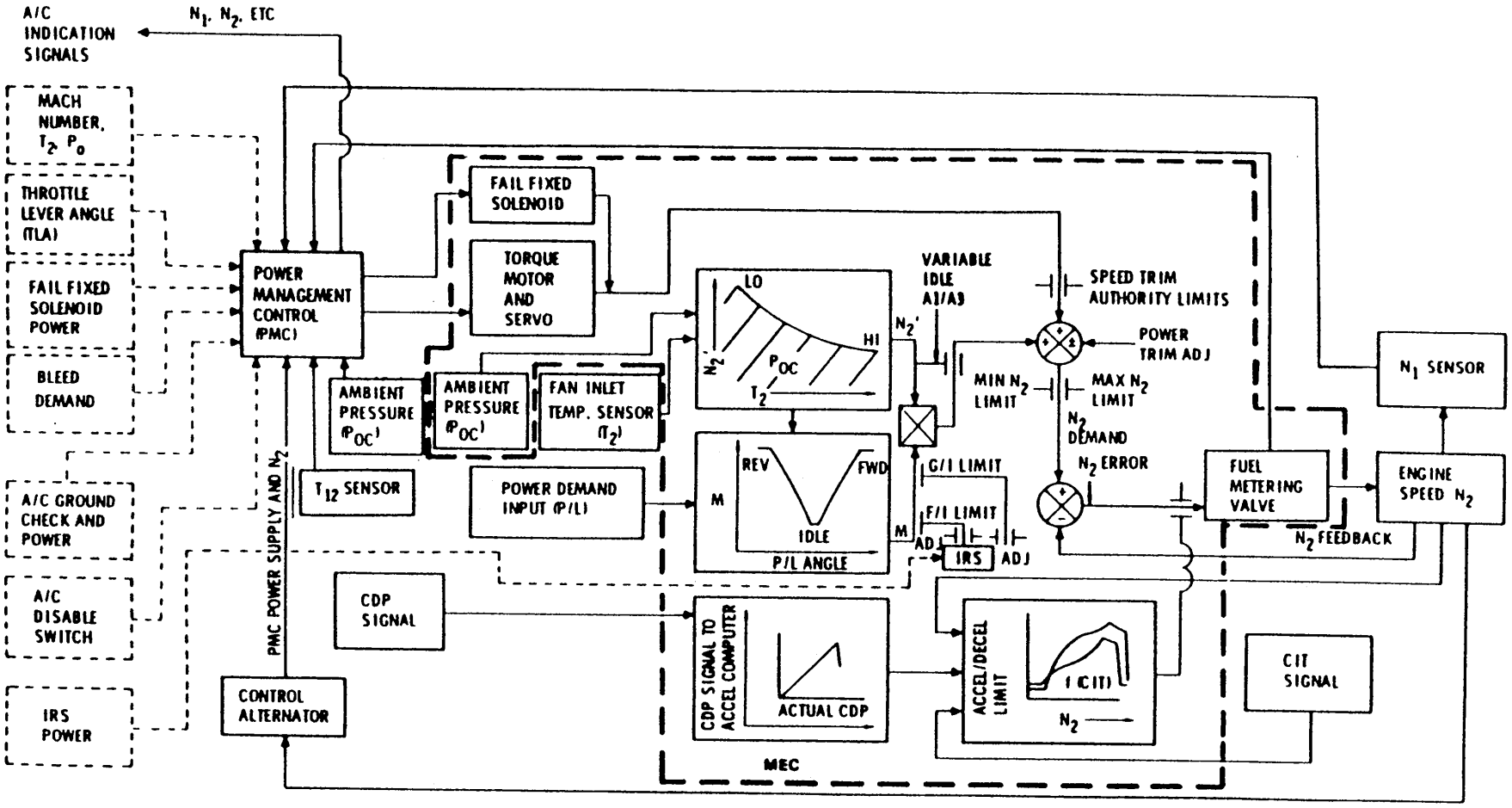
N2 overspeed trip -range 111.2- 112.2% N2 rpm. A redundant system to the fuel metering valve control system. This system increases fuel pump bypass flow as a function of rpm overspeed, thus reducing the combustion fuel flow to limit gross overspeed.

Corrected N2 speed cutback -N2, T2.5. A function of the corrected speed 3-D cam. Protects the engine from high EGT in extreme high ambient temperatures, and overthrust in extreme cold temperatures at high engine rpms. This is the prime overspeed protection system. It reduces the acceleration fuel limit schedule when excessive corrected N2 speeds are sensed.

Fail fixed
Fail fixes - electrical 28VDC to the solenoid. It locks at the existing degree of power trim when the PMC detects PMC system malfunctions.

Servo pressure regulation
MEC inlet fuel supply is used to develop servo pressure that position cams, and pilot valves. A pressurizing valve blocks flow to the fuel manifold until servo pressure regulation has been achieved. Pcr servo pressure and a spring force equivalent to 90 psi keep the valve seated until 240-300 psi above fuel pump boost pressures is developed. Priority is thus given to hydromechanical computer and servo pilot valve functions over the combustion fuel flow.

N1 Speed Control Schematic



Fuel Shutoff

Fuel shutoff control -a cockpit switch to an airframe motor drives the MEC fuel shutoff lever to open or closed position. It controls the fuel discharge shutoff valve in the MEC. In the closed position the lever also causes the bypass valve to open increasing the fuel recirculation to unload the pump. The lever moves 45^0 from closed to open, during which the fuel shutoff valve within the MEC is closed below 5 degrees. Positive stops are provided for both limit positions.

MEC Adjustments are VSV feedback (manual), VBV feedback (manual), minimum idle and approach idle speeds (manual and remote), and fuel specific gravity. Adjustments to the MEC provide for fuel/air regulation and trimming.

VSV feedback rig -(A310) an adjustable pivot for the reverser arm to which the VSV feedback cable rod end is bolted. The required position is referenced to the VSV rig marks.

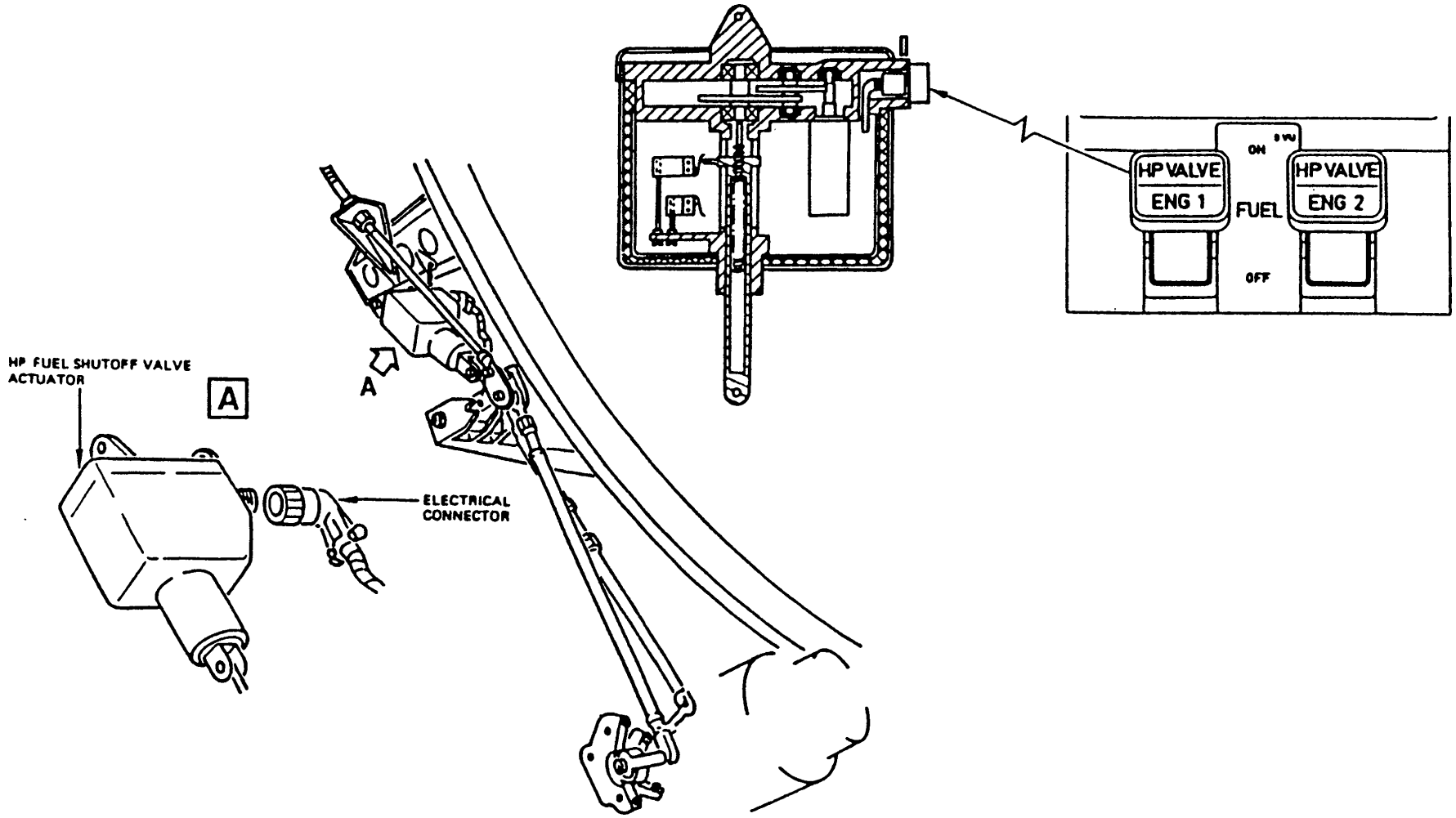
VBV feedback rig -an adjustable bracket to which the VBV feedback cable housing is clamped. The required position is referenced to the VBV rig marks.

Specific Gravity -An adjustment made by turning a socket head screw. It determines the differential pressure across the fuel metering valve to enable calibration of the flow with different fuels.

Minimum or ground idle adjustment -a socket head screw. Adjustment raises or lowers minimum idle rpm.

Approach or flight idle adjustment -a socket headscrew located under the minimum idle adjustment screw which must be removed to adjust approach idle. A wet port.

Fuel Shutoff Actuator



Operation

The hydromechanical MEC will control engine thrust accurately and reliably even if the PMC is deactivated. Thrust control is through the throttle operated push-pull cable to the MEC power lever. This signal, as applied through the MEC mechanism and hydromechanical computer, becomes a corrected N2 speed command on the governor controlling the fuel metering valve. The governor adjusts fuel flow to met the command. Corrected N2 speed, core speed corrected to T2 and ambient pressure Po, is directly related to N1 and thrust. Corrected N2 speed is a measure of the airflow in the core engine and the energy available to drive the fan.

The MEC computes the required speed from the parameters of power lever angle (PLA), fan inlet temperature (T2), ambient pressure (Poc). The result is a force upon a governor or speeder spring. N2 rpm is a feedback through the governor flyweights. The metering valve will supply a steady fuel flow when the flyweight force equals the spring force. When the speed requirement is greatly different than the existing N2, the governor authority over the metering valve is limited so that neither flame-out nor overtemperature and compressor stall develops. The MEC provides a hydromechanical computer sensing N2 rpm, compressor inlet temperature (CIT), and compressor discharge pressure (CDP) to calculate the maximum and minimum allowable fuel flows. The control system limits the fuel metering valve position within this range. This system delivers the maximum acceleration and deceleration rate the engine can stand within the limits of acceptable deterioration of that component.

The MEC is responsible for scheduling the compressor airflow control mechanisms. The variable stator vanes (VSV) and the variable bleed valves (VBV) are adjusted to a predetermined schedule based upon the core rotor speed corrected to T2. The object of the schedule is to provide an airflow match between the variable stages of the front and the aft fixed stages. Operating to the schedule will result in stall-free compressor service.

MEC

Fuel Flowmeter

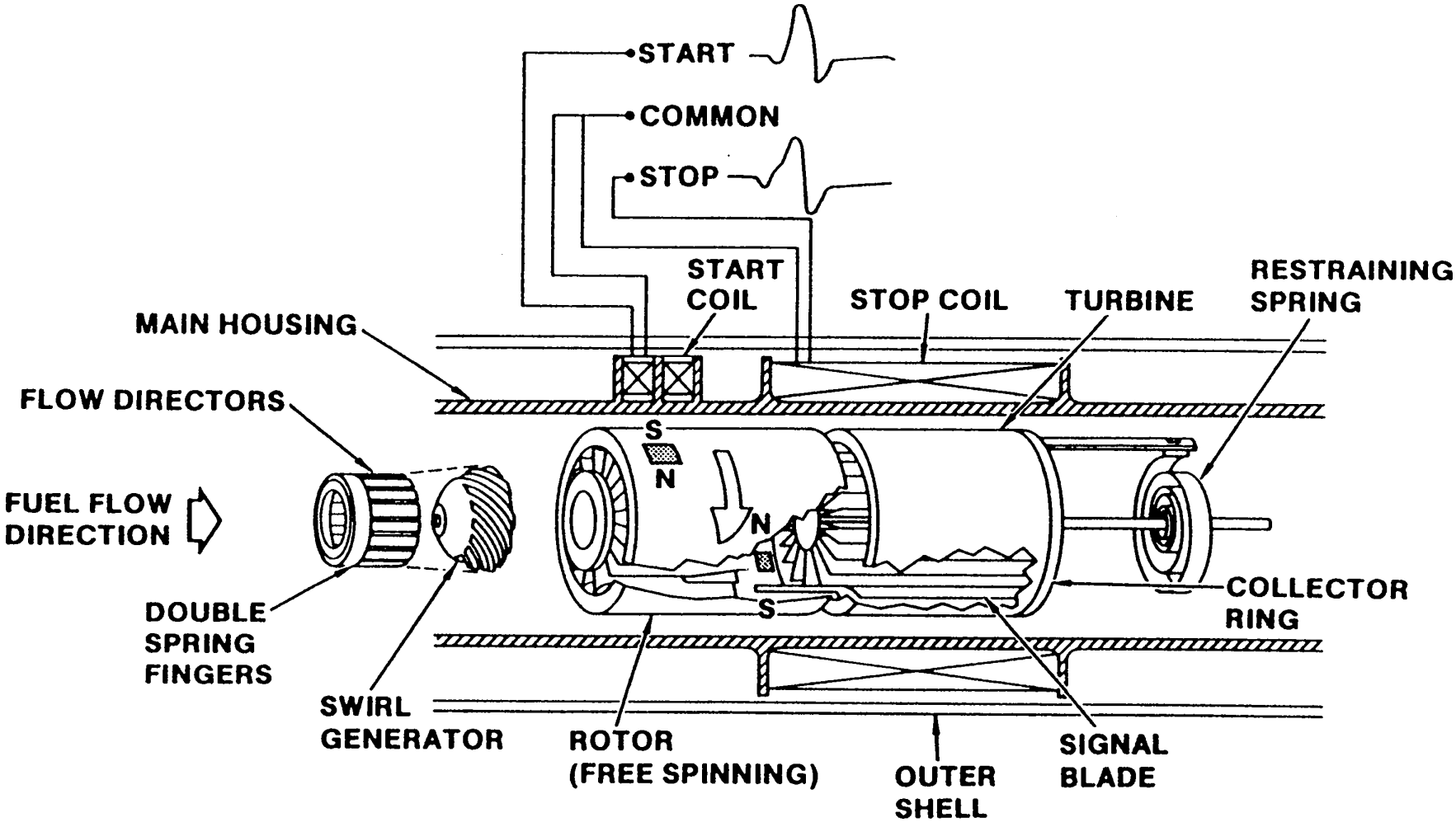
The flowmeter provides an electrical pulse signal to both the cockpit indicator and the performance multiplexer (PMUX) proportional to mass fuel flow in order that fuel consumption can be measured and recorded. The unit is electrically self energized when driven by the flowing fuel. On the A310, the flowmeter is supported by a clamp to a bracket at 7:00 on the engine next to the MEC. An electrical connector is also provided near the "fuel in" port.

Operation

Inlet fuel is directed thru a swirl generator to establish a vortex flow that drives the rotor. The rotor is a cylindrical, free spinning rotor mounted on ball bearings. The rotor contains two permanent magnets. One magnet is in the plane of the start coil. The second magnet is near the trailing edge and passes under the signal blade extension of the turbine. The free spinning rotor generates a start signal, electro-magnetic pulse in the start coil. A similar pulse is induced in the signal blade -collector ring circuit of the turbine by the aft magnet to produce a stop pulse in the stop coil circuit. The time lapse between the start and stop pulses is variable and proportional to the flow rate of the fuel. The turbine, like the rotor, is bearing mounted to be able to turn but is restrained from spinning by the restraining spring. The vanes in the turbine react to the swirling fuel flow. Depending upon the mass flow, the turbine will proportionally windup the restraining spring. The position of the single blade forward extension will be at an angular position commensurate with the spring windup.

A start coil is mounted outside the main housing to pick up the rotating forward magnet. A stop coil encircling the main housing is energized by the electromagnetic pulse generated by the second magnet of the rotor passing under the extension of the signal blade and collector ring circuit.

Fuel Flowmeter



Fuel Manifold

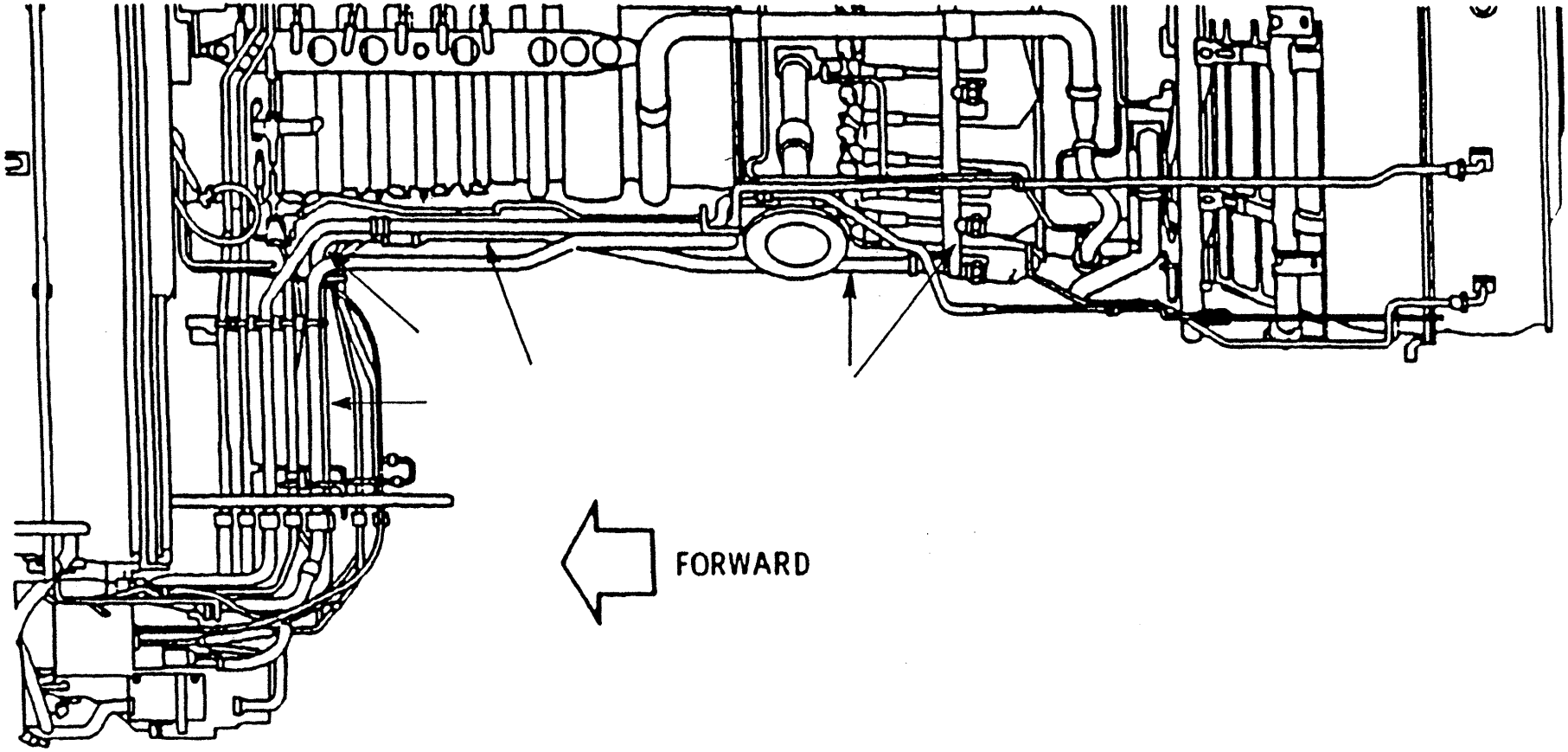
The fuel manifold carries the fuel from the MEC to the fuel nozzles. Non-shrouded lines below the lower pylon fireseal direct the fuel into the fuel flow meter installed on the transfer gearbox. Above the lower pylon fireseal the manifold is shrouded. The main parts are the pylon fuel tube which runs vertically to the underside of the compressor case. The next part is the fuel tube which carries the fuel horizontally aft to the flange coupling of the lower shrouded fuel manifold.

The shrouded manifold assembly sections each supply fifteen fuel nozzles through five shrouded fuel nozzle feeder tube assemblies or tribones. A recent change in design deletes the outer two knurled nuts at the fuel nozzle end from the tribone assembly and the lockwire from the Hex nut.

The shrouded manifold must be pressure tested at two levels of pressure. The high tube connections are tested for leaks at 200 psig, while the shroud is checked at 50-55 psig. No leakage permitted in the high pressure fuel line.

The shroud drains through the lower pylon fireseal into the drain mast module by an interconnecting drain tube.

Fuel Supply Tubes and Manifolds



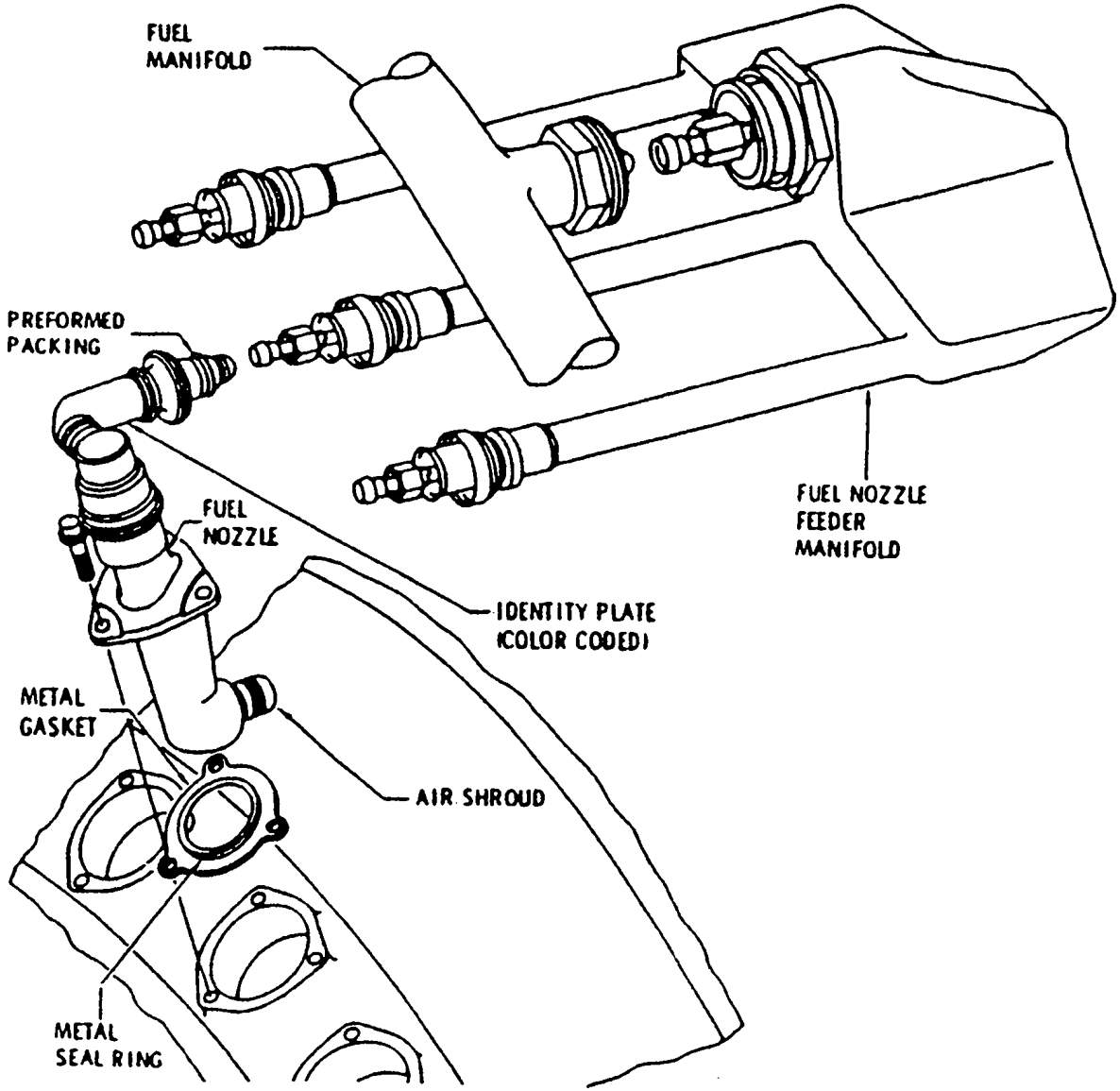
Fuel Feeder Manifold

Carries the fuel from the main fuel manifold to the nozzles.

A single unit that consists of three, jointly connected and schrouded fuel tubes that are connected to three individual nozzles.

Fuel schroud and fuel lines pressure checked much the same as the main fuel manifolds.

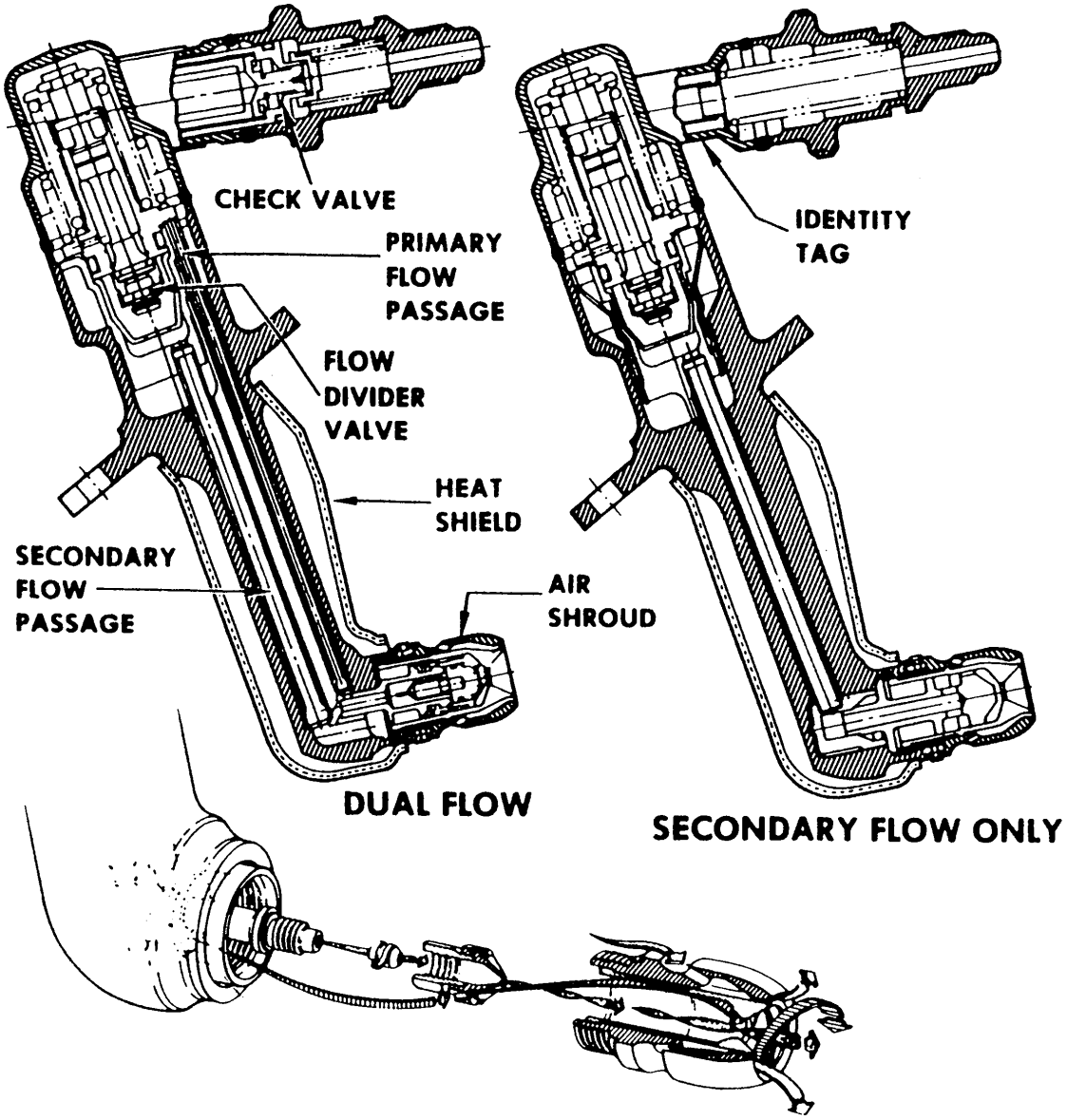
Fuel Feeder Manifold

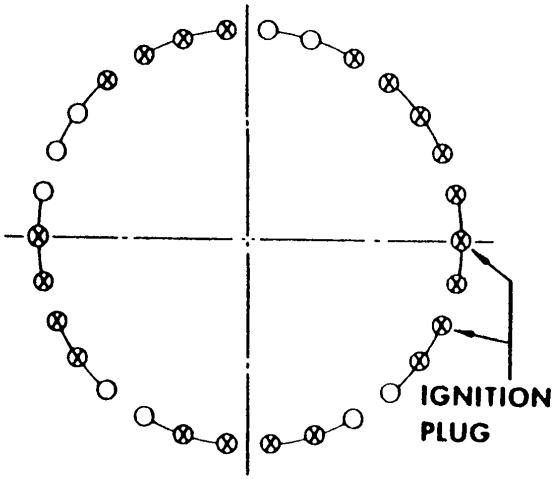


Fuel Nozzles

Thirty each (30) nozzles that deliver fuel into the combustor in a spray pattern which provides good light off, low emissions and efficient burning at high power . Twenty one nozzles provide both primary flow for light off and secondary flow for high volume fuel needed at power. Some nozzles do not incorporate primary discharge flow, but do provide secondary flow for high power. A green anodized tag identifies the secondary only nozzles. Part numbers are etched on the valve body. Dual flow nozzles contain a check valve, 20 psi +/- 2, at the fuel inlet to prevent fuel drainage at engine shutdown. Both types of nozzles contain a flow divider valve which initiates secondary fuel flow when the manifold pressure exceeds the burner pressure by 320-250 psid. No fuel flow from secondary only nozzles below approximate flight idle speed. The primary and secondary flows have separate swirl chambers to atomize that fuel. Atomization is aided by air circulation through the air shroud at the tip.

Fuel Nozzle





FUEL NOZZLE CONFIGURATION
AFT LOOKING FORWARD

⊗ PRIMARY/SECONDARY
○ SECONDARY ONLY

VBV and VSVs

A VBV position schedule is provided by a cam in the MEC. The cam position is determined by the VSV feedback cable position, which in turn is directly proportional to the engine speed corrected to T2.5. The cam positions a pilot valve controlling MEC inlet fuel pressure. As in the VSV system, the fuel pressure will drive the hydraulic actuators that position the VBV's. A feedback cable will null the pilot valve signal when the actuators are in the required position. The MEC must be rigged to the VBV actuators by a feedback cable adjustment.

The position of the VSV's and the VBV's may be monitored while the engine is operating using the linear variable displacement transducer (LVDT) sensors of the Condition Monitoring Kits. The LVDT's are attached to brackets at prepared bosses and connected to electrical cables to carry the signal. Indicators in the flight deck will display the respective system position calibrated in degrees or volts of VSV position and volts of VBV position.

VBV and VSVs

VSV System

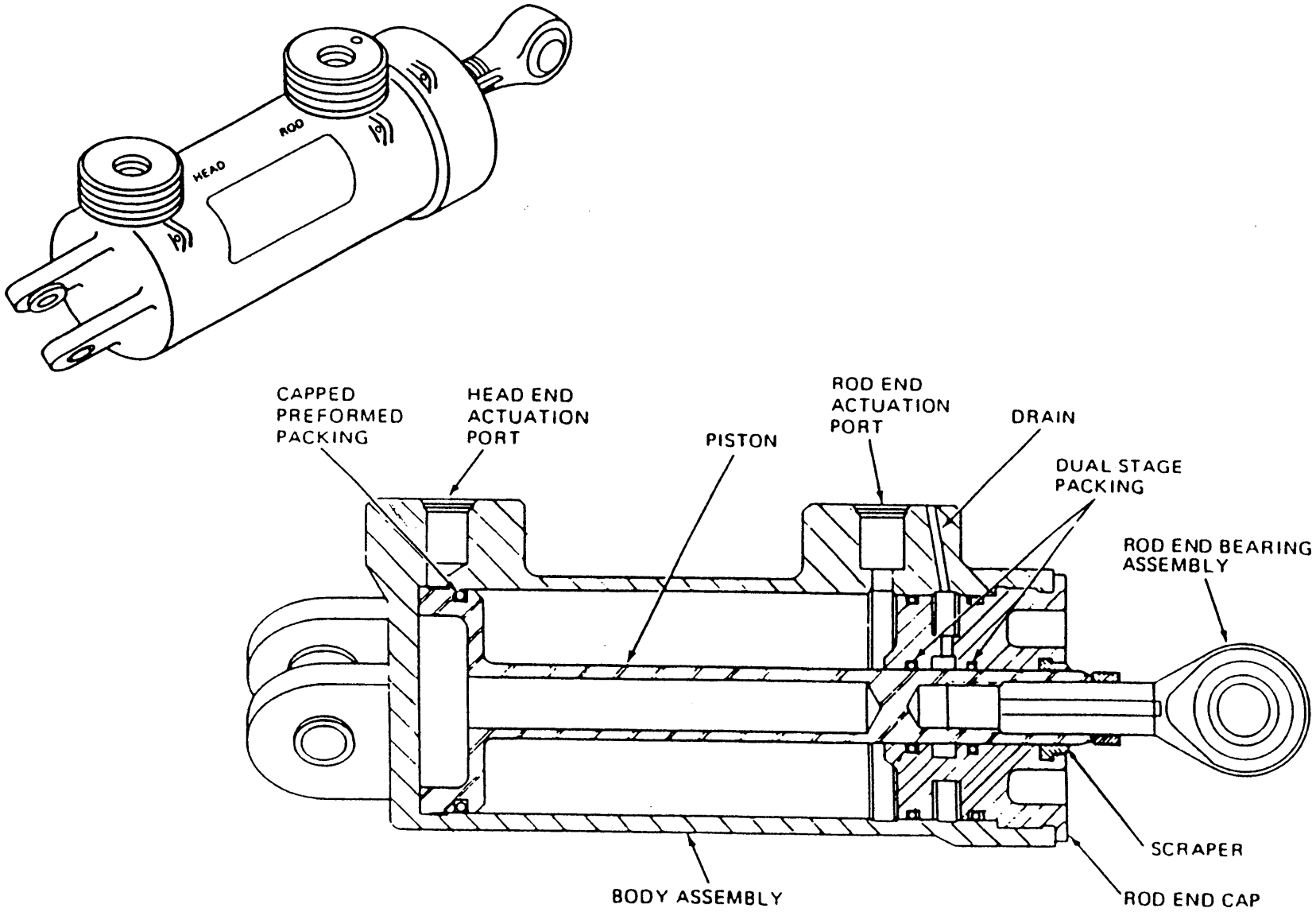
The components of the VSV System are:

- VSV Hydraulic Actuators (2)
- VSV Feedback Cable and Linkage

Variable Stator Vane Actuator (mounted at 3 and 9 o'clock forward flange compressor stator).

- Double acting hydraulic piston. Actuation fluid is fuel at MEC inlet pressure.
- Fixed stroke limited by head end and end cap.
- Double seal with seal drain, “Viton B” packing. Seal drain into rod end fitting boss and fuel line shroud.
- Rod wiper -Teflon.
- Rod end bearing provides adjustment for actuator length, not field adjustable or repairable.
- Full open actuator is baseline reference for rigging compressor VSV’s to MEC.

VSV Actuator



VSV and VBV Feedback Cables

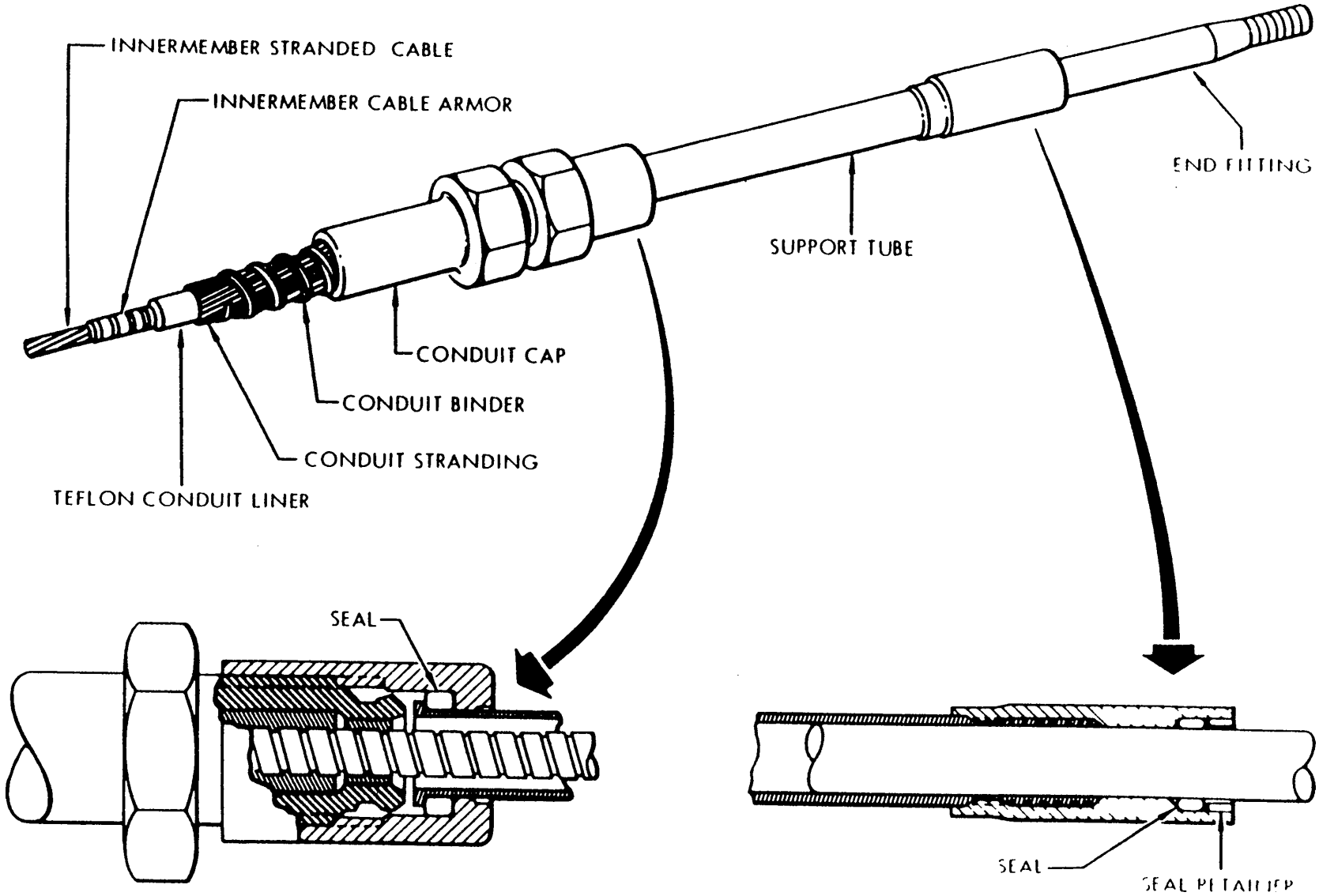
Construction

The inner member of the cable is stranded steel wire with a polished strap spiral wrapped around the strands to bind them. An end is swaged to the stranded cable each end. The rods are threaded for rod end bearing attachment. The outer housing is a flexible braided conduit with a teflon liner inside. The housing is attached to an end fitting which is threaded for assembly of the support tube and to attach to the split eye type support brackets. The support tubes direct the flex cable into the housing. They are sealed to reduce airflow and passage of contaminates by "0" ring seals. The VBV feedback cable is constructed like the VSV feedback cable. The principle difference is the length.

Routing on the engine

The feedback cable inner member originates at a bellcrank at the nine o'clock position while the conduit starts by clamping to the lever arm of the feedback cable reset actuators. It is routed down through the lower pylon fireseal, then to the MEC. The VBV feedback cable originates at the nine o'clock fan frame position. It runs down to the lower pylon fireseal then over to the MEC at seven o'clock.

Feedback Cable



VBV System

Variable bleed valve actuator

A double acting hydraulic piston using MEC fuel at inlet pressure as the actuation force.

Fixed stroke limited by head and rod end stops.

Dual stage seal with a drain between the first and second stages. The drain is vented to the fuel line shroud.

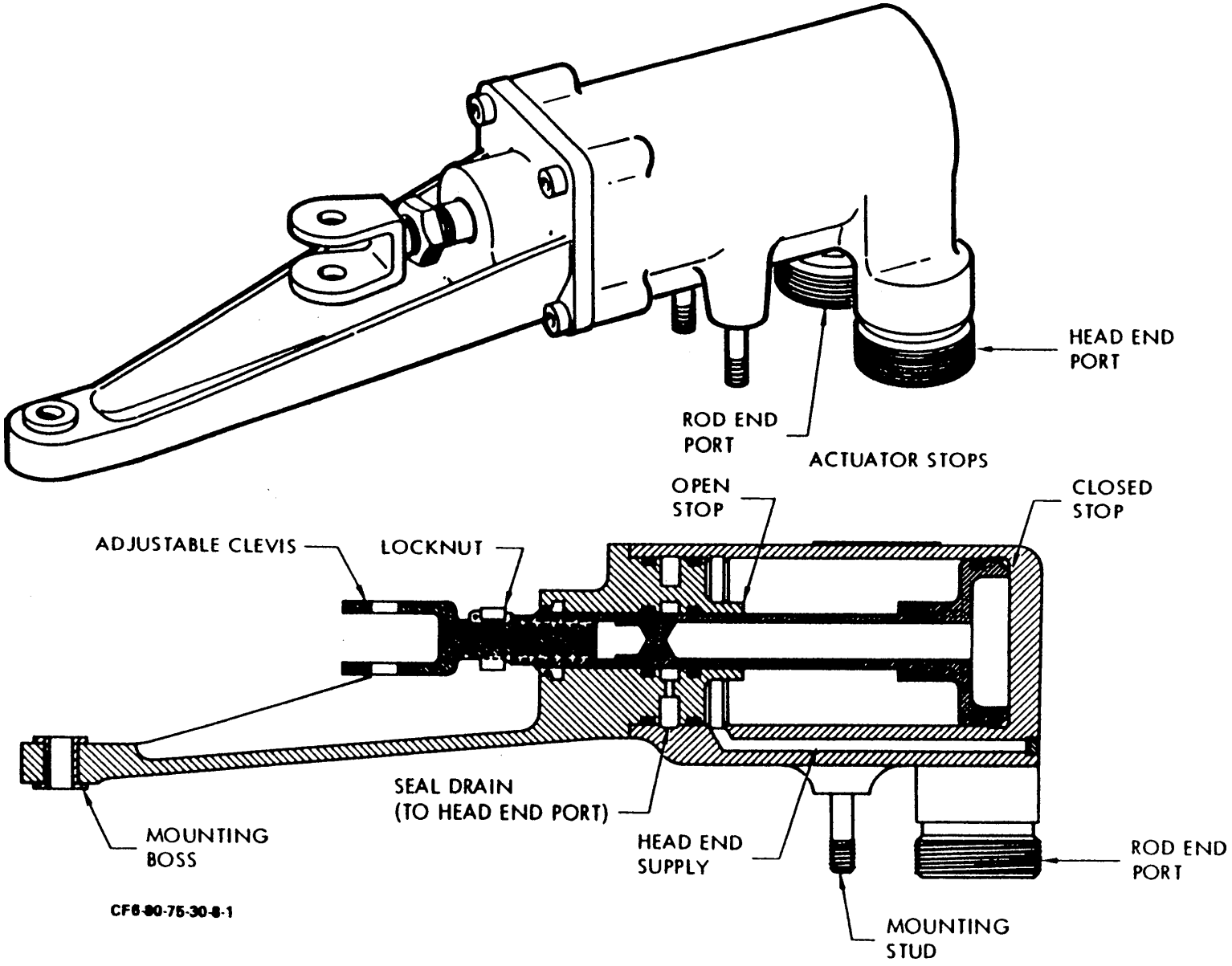
Rod wiper of Teflon.

Mounted by two studs at one end and bolted through a slip fit bushing at the forward end.

Adjustable clevis on piston rod to provide accurate actuator rigged length. The assembly is not field adjustable.

Full closed actuator is baseline reference for rig of VBV's to MEC.

VBV Actuator



VSV Feedback Cable Reset System

The VSV/VBV reset function, is used during throttle chop. It provides an increased compressor stall margin during thrust reversing.

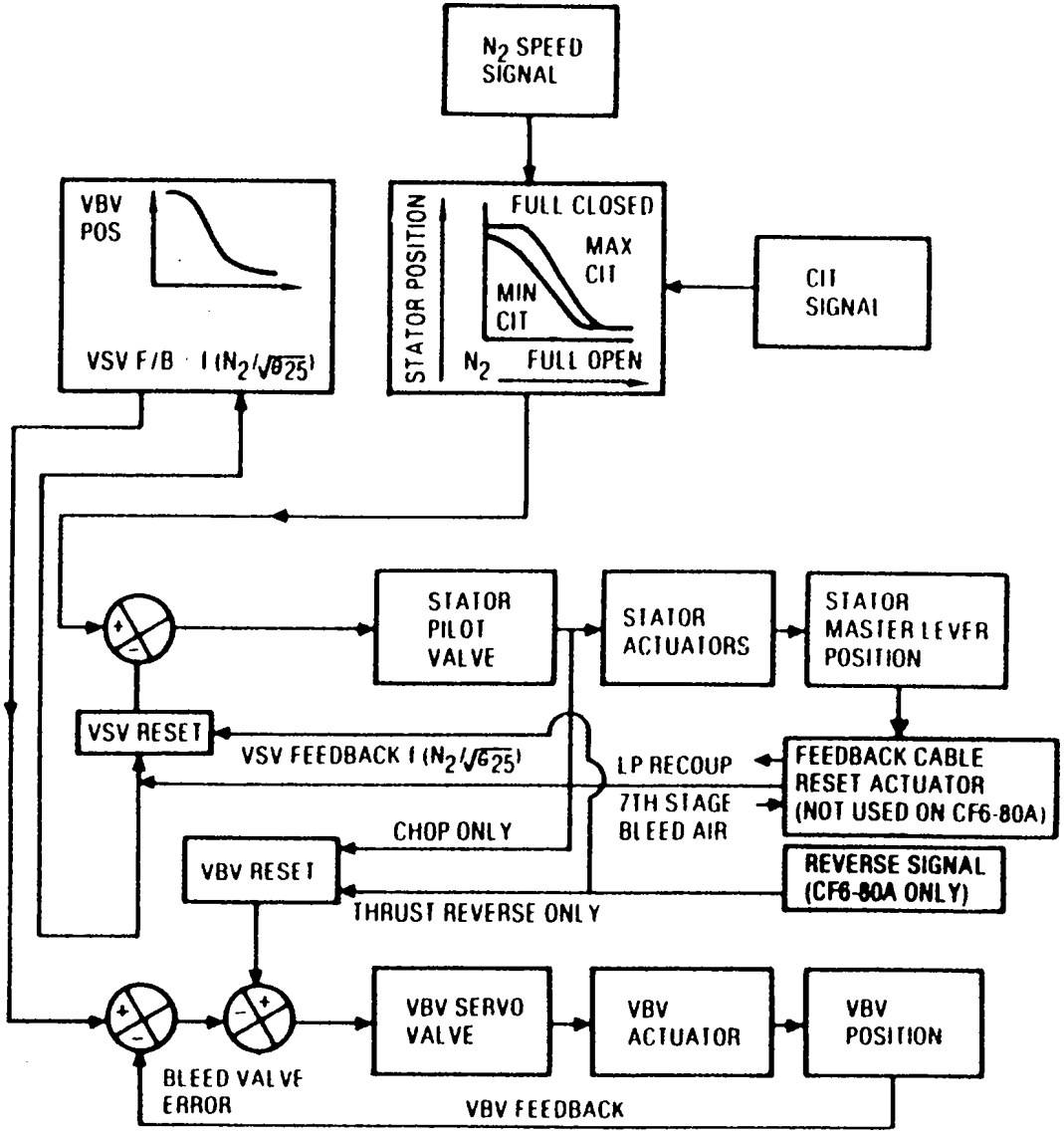
The feedback cable reset actuator transiently repositions the VSV feedback cable during engine acceleration. When takeoff power is set, the VSV's are reset closed initially and then gradually returned to the scheduled position. This reset action provides partial compensation for the inherent tendency of fan speed and exhaust gas temperature (EGT) to both overshoot initially and then droop below target at fixed throttle. It also provides increased compressor stall margin at takeoff.

During a rapid acceleration the clearances in the HPT open up with resultant loss of efficiency, higher fuel flow requirements and EGT. Fortunately the seal placement and growth characteristics of the LPT are such as to improve its efficiency during the same transient. The LPT can produce more fan speed from a given airflow during a throttle burst transient than it can with the same given airflow under steady state conditions. Fan speed will overshoot the high energy level in the core engine gas flow.

Compressor Control Systems Diagram

ABBREVIATIONS USED

CIT	COMPRESSOR INLET TEMPERATURE
N_2	H P ROTOR SPEED
LP	LOW PRESSURE
θ_{25}	CORRECTED TOTAL TEMP AT CORE INLET
F/B	FEEDBACK
VBV	VARIABLE BLEED VALVE
VSV	VARIABLE STATOR VANE



VSV Feedback Cable Reset Actuator

The actuator will sense the transient situation and will make a change in the feedback cable loop, closing the vanes, reducing the airflow, fuel flow, and EGT overshoot, while the N1 will continue to be driven to acceptable speeds.

Seventh stage compressor bleed air is ducted through the actuator to heat the primary tube and secondary rod sensor unit. The sensor tube and rod can be compared to a thermal model of the engine. With increases of N2, the 7th stage bleed is being compressed and heated. The flow through the actuator increases in temperature and BTU content causing a thermal transient condition to exist here too.

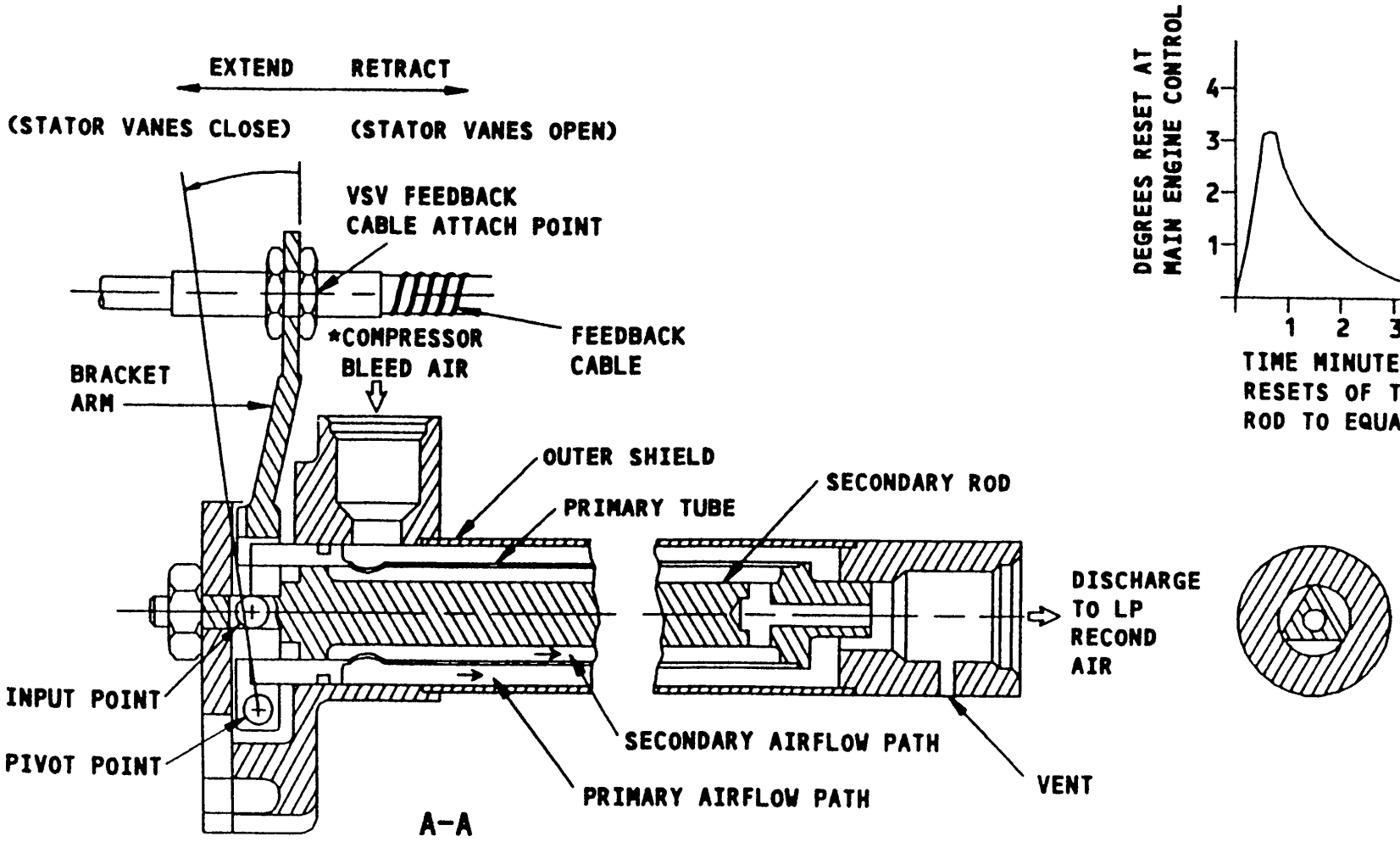
The primary tube is free to expand to the left but is welded or brazed to the secondary rod on the right end. The secondary rod cannot expand as rapidly as the primary tube. It is much heavier in cross-section. There is then a differential in their respective lengths during the transient similar to that dimensional change seen in the engine between the stators and the rotors.

A bracket arm supporting the upper end of the VSV feedback cable sheath is pivoted to the outer case of the actuator and moved at the input pivot by the expansion of the primary tube. The bracket arm swings counterclockwise shortening the feedback cable loop on an acceleration. The bracket arm is returned to null, with the passage of time, as both sensor units assume a new stable dimension at the higher temperature. But in growing to the new length, there is a time delay between the two elements of approximately 180 to 300 seconds in the maximum condition.

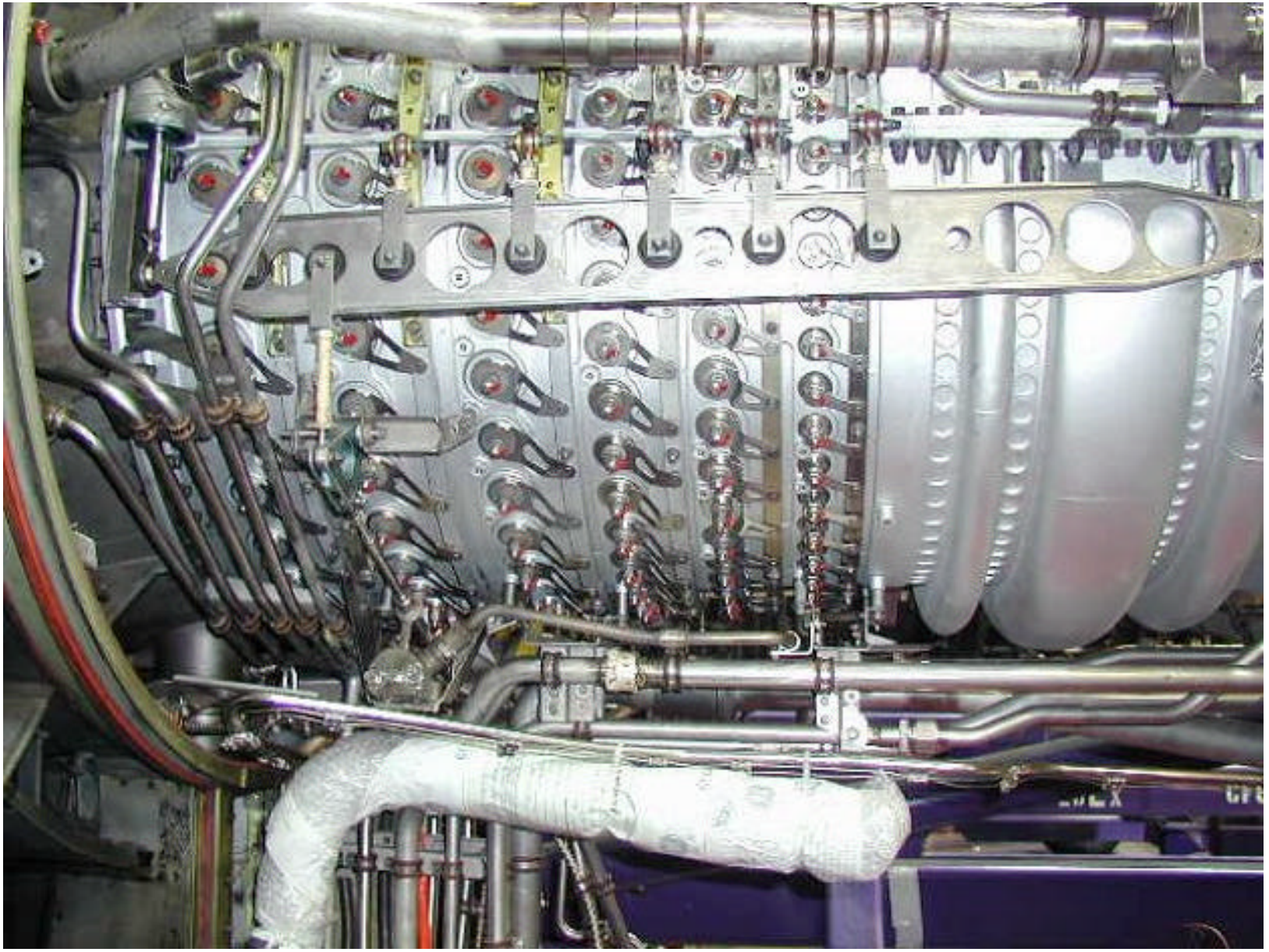
When the secondary rod becomes the same temperature as the primary tube, it has . expanded to the right, pulling with it the primary tube and the bracket arm. It, the secondary rod, is bolted firmly to the housing on the left and is free to move axially within the bore of the discharge air flow on the right.

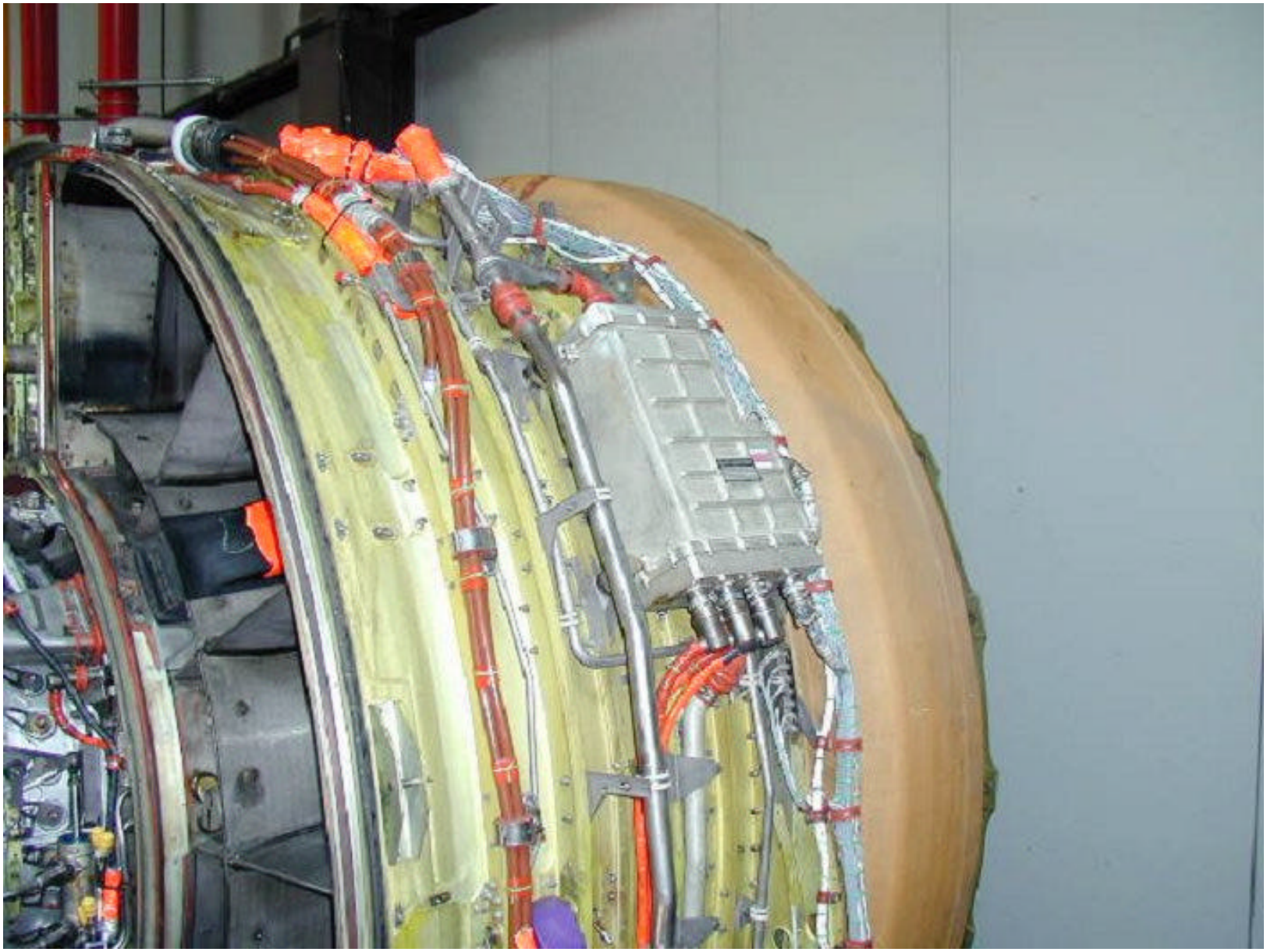
The closure of the vanes reduces the power required of the HPT to drive the compressor. It tends to cause overspeed in the rotor but it's corrected in the MEC by governor action on the fuel metering valve to reduce fuel flow. The reduced fuel flow reduces EGT. The improved transient efficiencies in the LPT use the reduced air flow to accelerate the fan to the target N1 without overshoot.

VSV Feedback Cable Reset Actuator



VSV Feedback Cable Reset Actuator



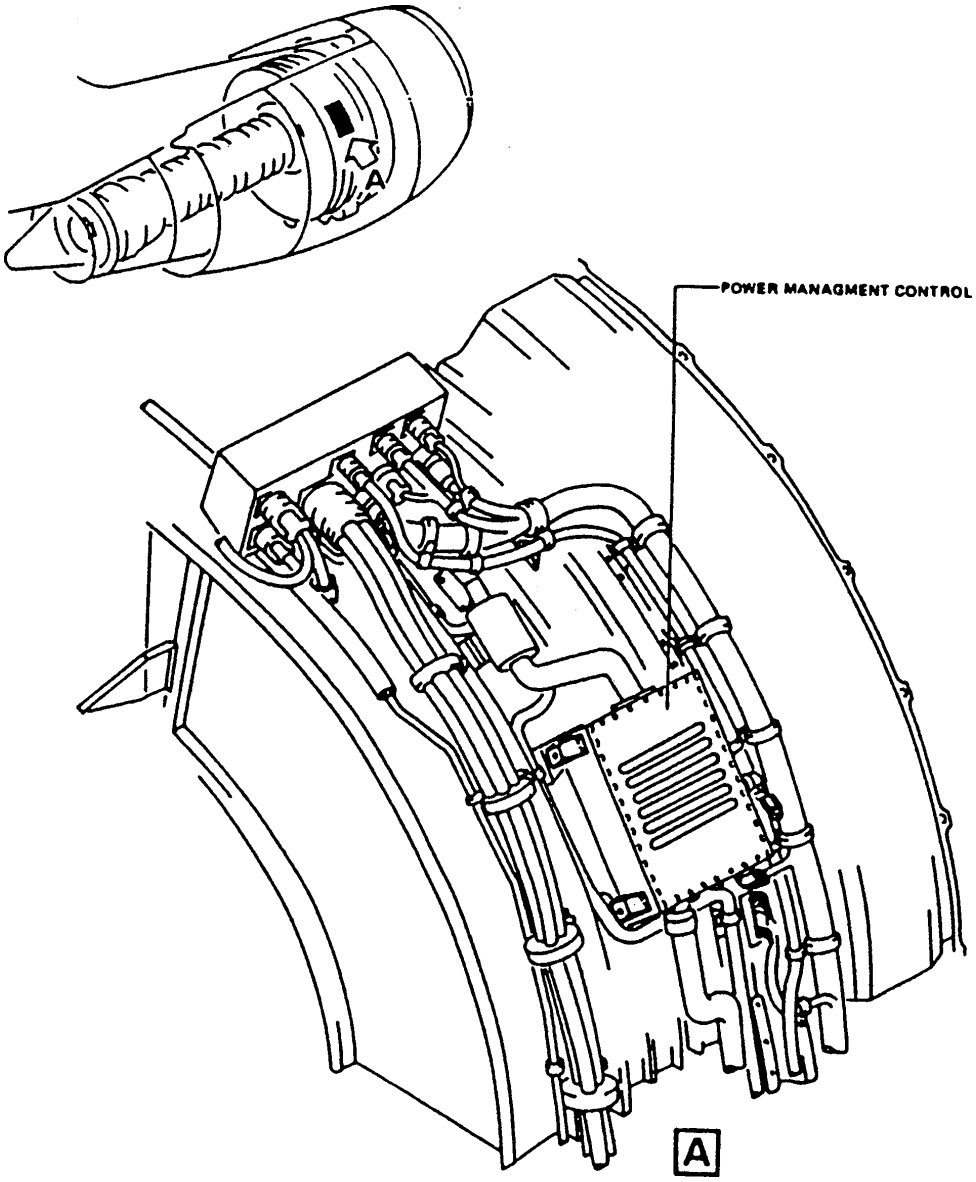


Fail Fixed Mode

The fail fixed mode will fix or maintain whatever amount of down trim has been made on the main engine control. This could range from zero to maximum down trim. The effect of "fail fixed" activation would require the pilot to manually adjust the throttle position to obtain the rated N1 rpm. The amount of adjustment would be minor since the MEC contains a HM T2 and Poc 3D cam, biasing the throttle speed signal to provide a corrected N2 speed of the engine. This will permit a close approximation of the required throttle position to give the N1 required. It is expected the extra throttle adjustment needed could be as little as 2° or 3° in the retard direction, depending on ambient conditions.

A switch(s) in the cockpit permit the pilot to select the PMC enable (On), or disable (Off). The switches are identified differently on the different aircraft applications, but the interface with the PMC is the same. If the PMC (s) is/are selected "off' or "inop.", engine thrust management is then entirely controlled by manual throttle positioning. This switch selection removes control from the MEC torque motor, preventing any down trimming operation and releases any fail-fixed latch, if previously set. All other internal/external functions of the PMC continue.

Power Management Control



Power Management Control (PMC)

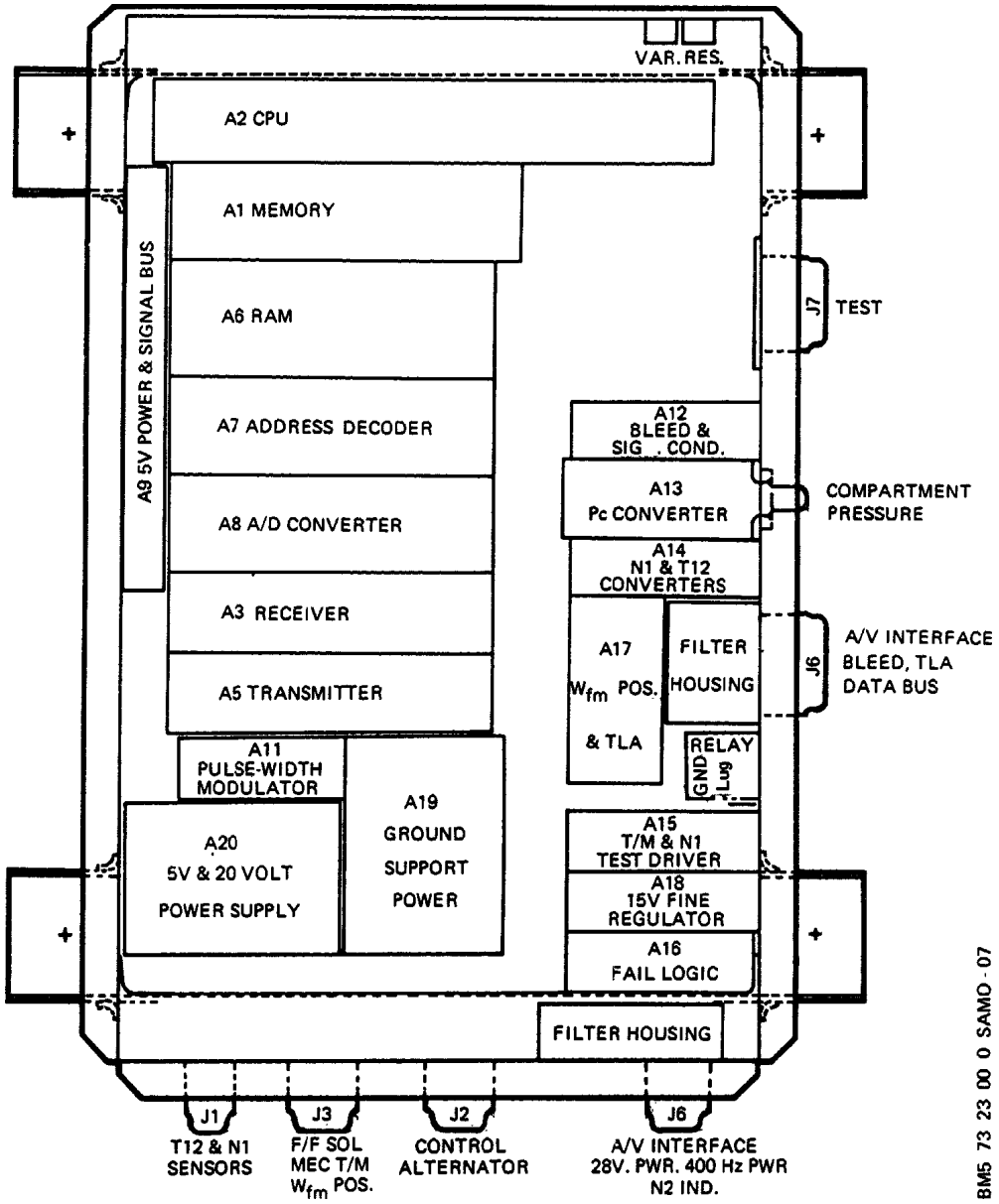
The PMC is a limited authority digital electronic trim control. The PMC is given an analog signal of throttle position via a resolver installed under the pilots control stand. The PMC also receives a combination of up to 6 aircraft bleed status input signals. Depending on aircraft application, other inputs of ambient pressure, mach number ,total air temperature, impact pressure, and total pressure are provided. The PMC uses these values to compute the required N1 command for the current day conditions and flight mode. The PMC will primarily use the aircraft inputs, performing status checks, range checks, etc. and compare this data with input data of the PMC sensors.

If the comparison shows agreement, then the PMC function of comparing actual N1 with the calculated N1 command will activate the torque motor drive circuit and trim the MEC downward, reducing N1 speed. The system dynamics cause the trimming to occur so that no overshoot of N1 command will be evident-

A disagreement between redundant sensed values will cause the PMC logic to discard the discrepant value, basing its computations on any like sensor values in agreement. The PMC will use it's engine mounted sensor data should the aircraft source fail the input test selection logic. The PMC will alert maintenance of any discrepancy on the aircraft maintenance panel.

Acceleration to takeoff power and the subsequent aircraft takeoff maneuver will cause a transient condition to develop in the thrust ratings. Normal changes in Mn, T2, Po and inlet recovery effect on the N1 rpm will see the thrust management computer updating the ratings calculations and adjusting the target bug. The PMC dynamics will drive the torque motor to adjust the MEC trim adjustment to compensate for the transient. The actual N1 will adjust as the target bug is updated and a "hands-off' throttle takeoff is accomplished.

Power Management Control



The PMC unit weighs about 40 pounds. Much of the weight is accounted for by the aluminum flake filled silicone rubber potting compound to protect the components against vibration shock, and heat.

The PMC receives dual ARINC 429 digital word signals from the aircraft. The PMC can generate a Mach number schedule in the absence of the aircraft digital words to enable computation of thrust ratings. The PMC subtracts impact pressure from total pressure to obtain Po, the altitude value.

Power for PMC operation is from the engine mounted control alternator except in the ground test mode. The PMC uses aircraft 28VDC to energize the "fail fixed" solenoid.

Ground test of the PMC uses 115V 400Hz from the aircraft power supply. When operating, the control alternator output disables the ground power test circuit. A thermal relay protects the PMC from excessive temperatures, deactivating ground test when it gets too hot.

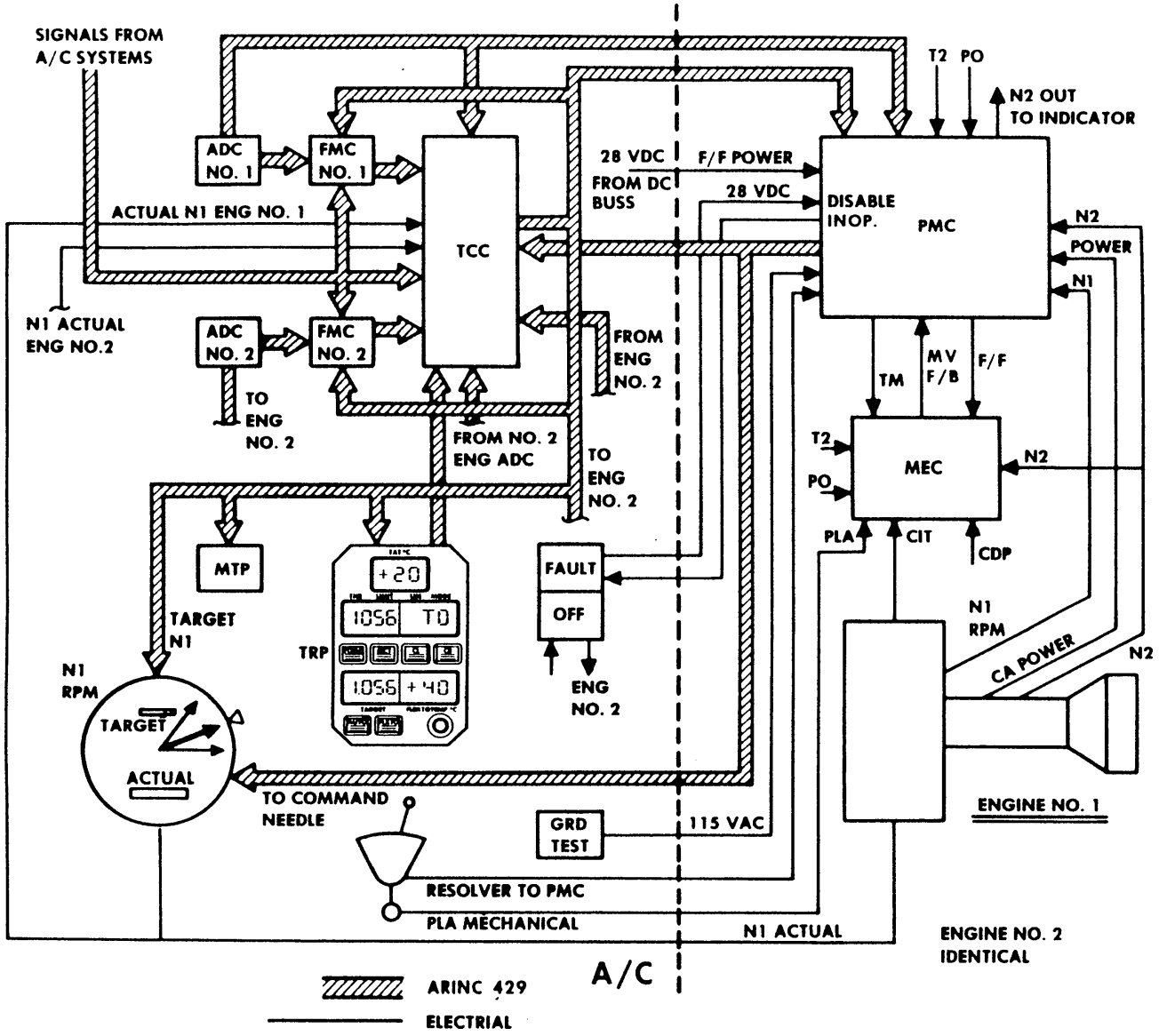
PMC INPUTS
Aircraft
Mach number (Mo) (A310), source ADC's
Total air temperature (TAT), source ADC's
Total pressure (Pt), source ADC's.
Impact pressure (a), source TCC (A310) note: the PMC computes Po from inputs of a and Pt
Discretes: enable/disable signal, bleeds status inputs, ground test signal/power input, TLA resolver ,

Engine
control alternator power/N2 signal
Ambient pressure (Poc)
Ambient (inlet) temperature (T1.2)
N1 actual
N1 demand (N1 DMD) metering valve feedback from MEC

PMC OUTPUTS
Aircraft
N1 actual (digital) (N1 ACT) to aircraft N 1 indicator
Command fan speed (N1 CMD) to aircraft N1 indicator
Maximum N1 limit (N1 MAX) to aircraft N1 indicator
PMC fault data to AIDS (A310)
PMC fault signal to cockpit panel lite

Engine
Torque motor current (TMC) to MEC
Data retrieval (from J7 connector)

Power Management Control System

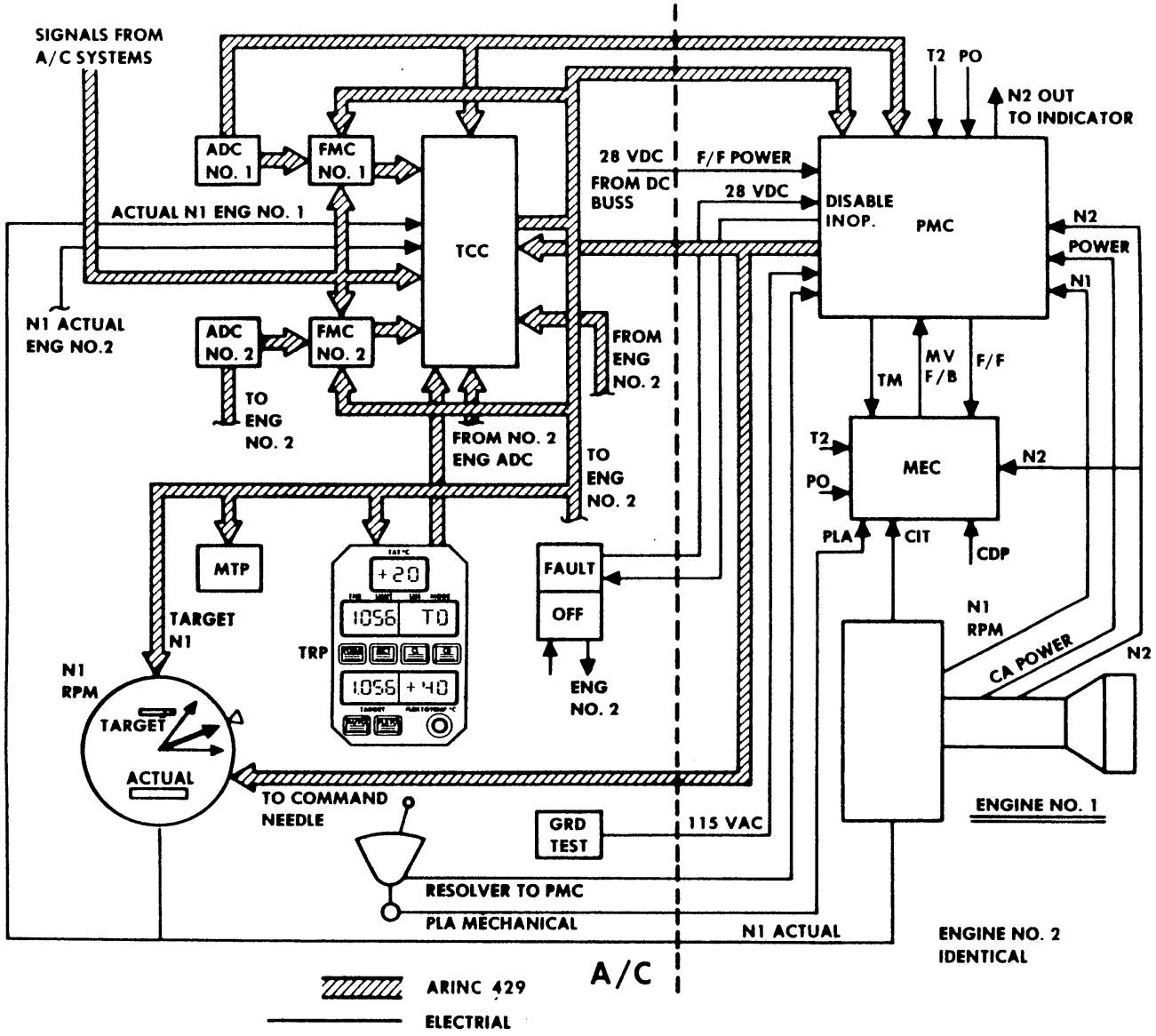


Within the A3l0 cockpit the N1 gage is a dial type. They are a target bug, a command needle, actual N1, digital N1, overspeed trip, overspeed redline, and self test capabilities (bite). The A310 aircraft, uses a single "engine trim" (FAULT -OFF switch) to control the PMC's of both engines. The switch is located on the overhead panel. Identified system and component faults can recalled using a portable test unit plugged directly into the aircraft digital data buss, or on certain model aircraft, read directly from the aircraft AIDS system. The connector is on the Flight Deck Maintenance panel. A digital display is provided on the Maintenance Panel to identify limited PMC faults.

The A3l0 aircraft is slightly different in the the prime digital input to the PMC is from the aircraft thrust control computer (TCC). The TCC provides Mach number (Mo), total air temperature (TAT), impact pressure (Pq), total pressure (Pt). The PMC uses these values to compute the N1 command and to compare with its own T2 and Po sensor values.

The aircraft bleed configuration effect on N1 target is programmed by the Thrust Control Computer. A manual throttle adjustment will be required to the new target.

Power Management Control System



Ground Test

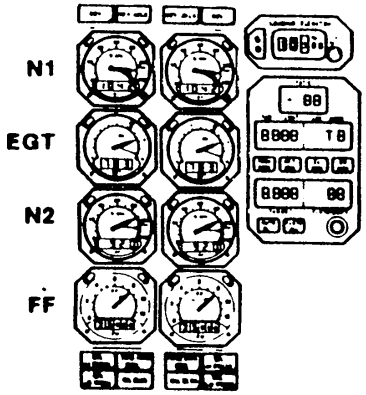
The PMC operation can be checked on the ground. When the engine is shutdown, an aircraft PMC ground test switch (Trim Test) on the flight deck supplies 115V 400 Hz signal which activates the PMC ground test program.In ground test, the PMC computes N1 command as in normal operation, and sets the N1 actual equal to the N1 command and provides digital outputs to the aircraft N1 indicator . When the throttle levers are moved, simultaneously the N1 actual and N1 command pointers on indicator move accordingly. This test provides a comparison of the PMC system operation of one engine with respect to the other. During this ground check, the PMC self monitoring system is fully operational and indicates any detected faults. The NVM maintains 7 sets of the above data, resulting from the last 7 flights (power on / power off). The last set is addressable while in ground test mode with the PMC disabled. The six remaining sets of data are available from the J3 test connector . The PMC has a thermal switch which prevents extended ground test operation in hot day ambient conditions, with settings of 165 deg.F maximum, or 100 deg.F for limited 30 minutes of operation.

The non-volatile memory (NVM) within the PMC stores a set of data which includes: 5 maintenance and system discrete words 8 sensor values (N1, N2, T1l.2, Po, TLA, N1DMD, Mo, and TMC).

sensor values (N1, N2,T1.2, Po, TLA, N1DMD, Mo and TMC)

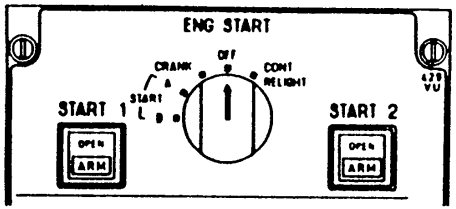
The NVM maintains 7 sets of the above data, resulting from the last 7 flights (power on / power off). The last set is addressable while in ground test mode with the PMC disabled. The six remaining sets of data are available from the J3 test connector .

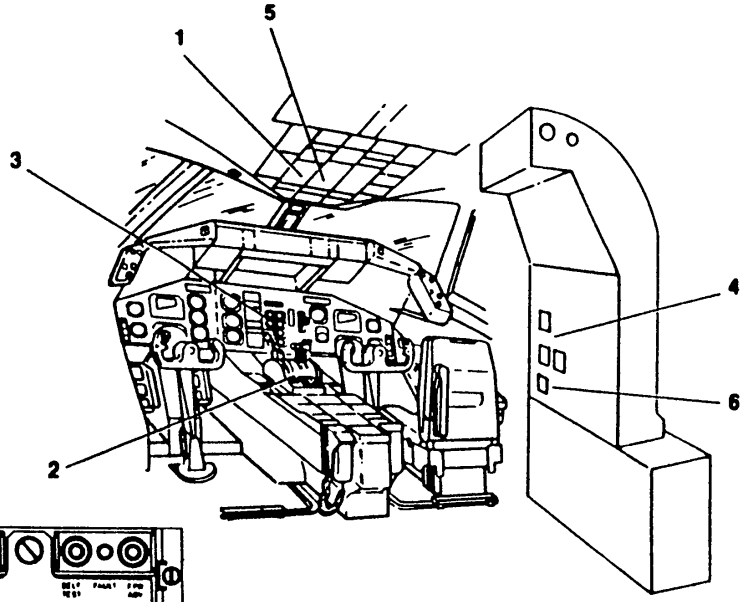
3. ENGINE INDICATING & TRP



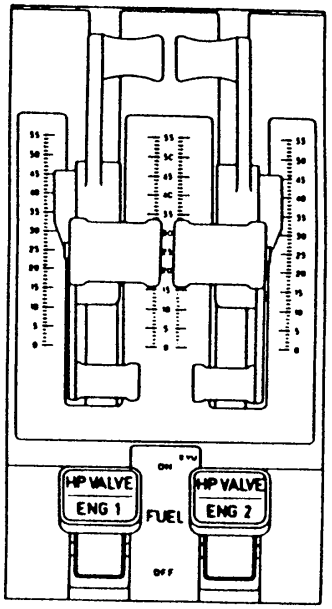
CF6-80-72-00-39-1

5. START AND IGNITION

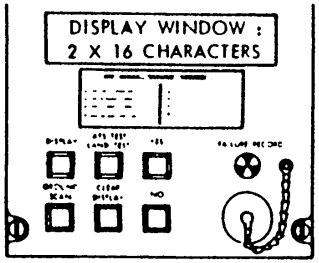


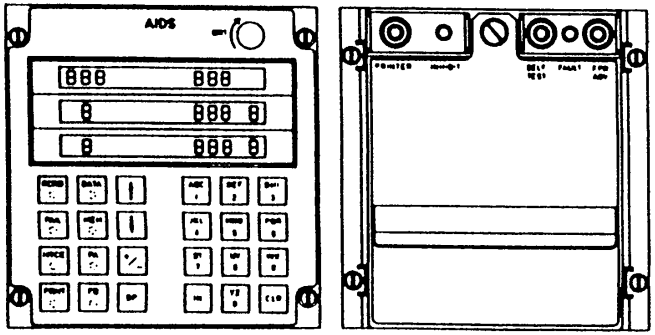


2. THROTTLE & FUEL SWITCH

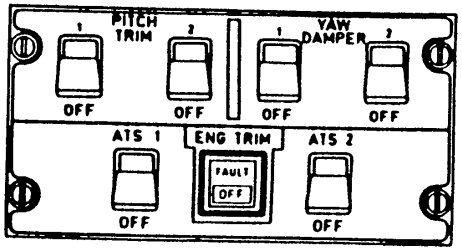


4. PMC FAULTS

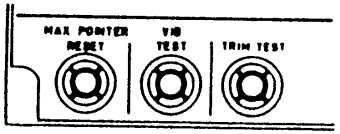




1. PMC SWITCH



6. PMC GROUND TEST



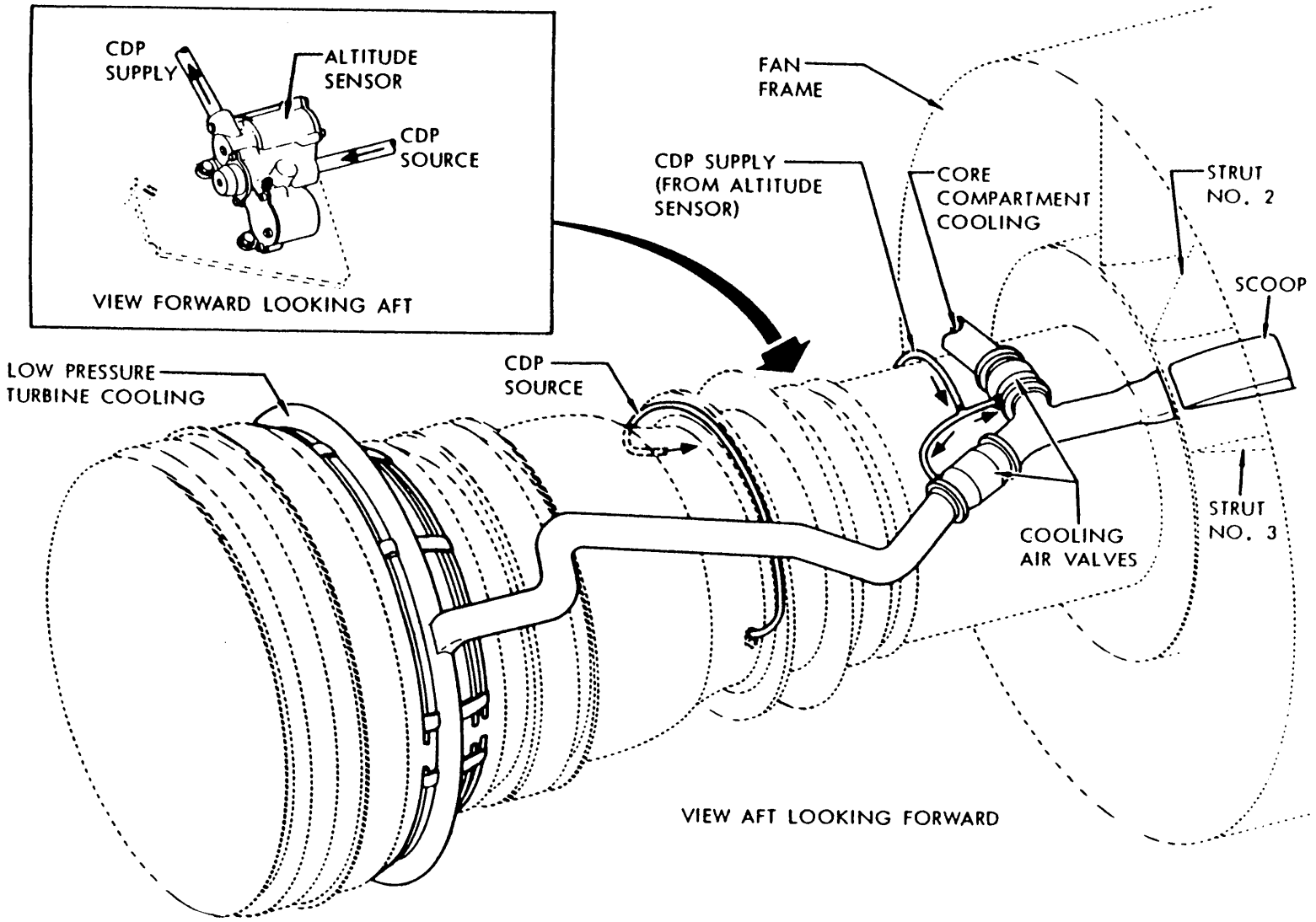
Active Clearance Control System

The system provides a fan discharge cooling air flow into the core engine compartment and to the low pressure turbine case cooling manifold. The two areas benefit from the cooling flow at different conditions during the aircraft flight so a selective use of the same cooling air source is possible through a manifold with a one and two shutoff valves.

The core engine develops higher compartment temperature during takeoff thrust and climb thrust, especially at lower altitudes, therefore core compartment cooling requirements place a greater demand on the cooling flow available. During this period the cooling air valves direct most of the air to the under cowl cooling manifolds. At the cruise altitudes the engine is throttled back, reducing the core engine and compartment temperatures and permitting a reduction in cooling air flow.

The low pressure turbine cooling manifold is supplied with a reduced flow through its normally "closed" air control valve at takeoff and climb modes up to about 20,000' altitude. Above this altitude the valve will open to provide an increased cooling flow to the LPT case. The increased cooling flow will cause the case to cool off and shrink somewhat. The shrinkage will close up the seal clearances producing an improved efficiency at the cruise altitudes which reduces the fuel burn.

Active Clearance Control System



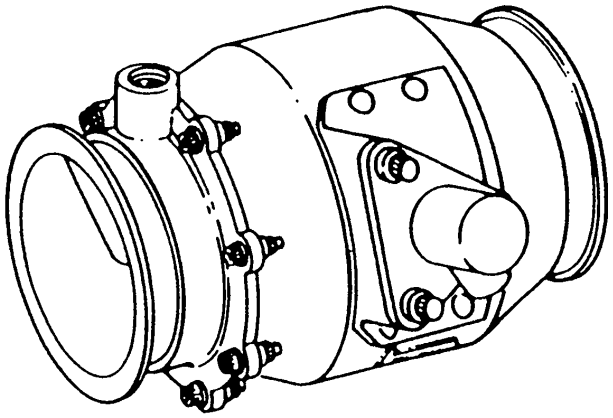
Cooling Air Valve

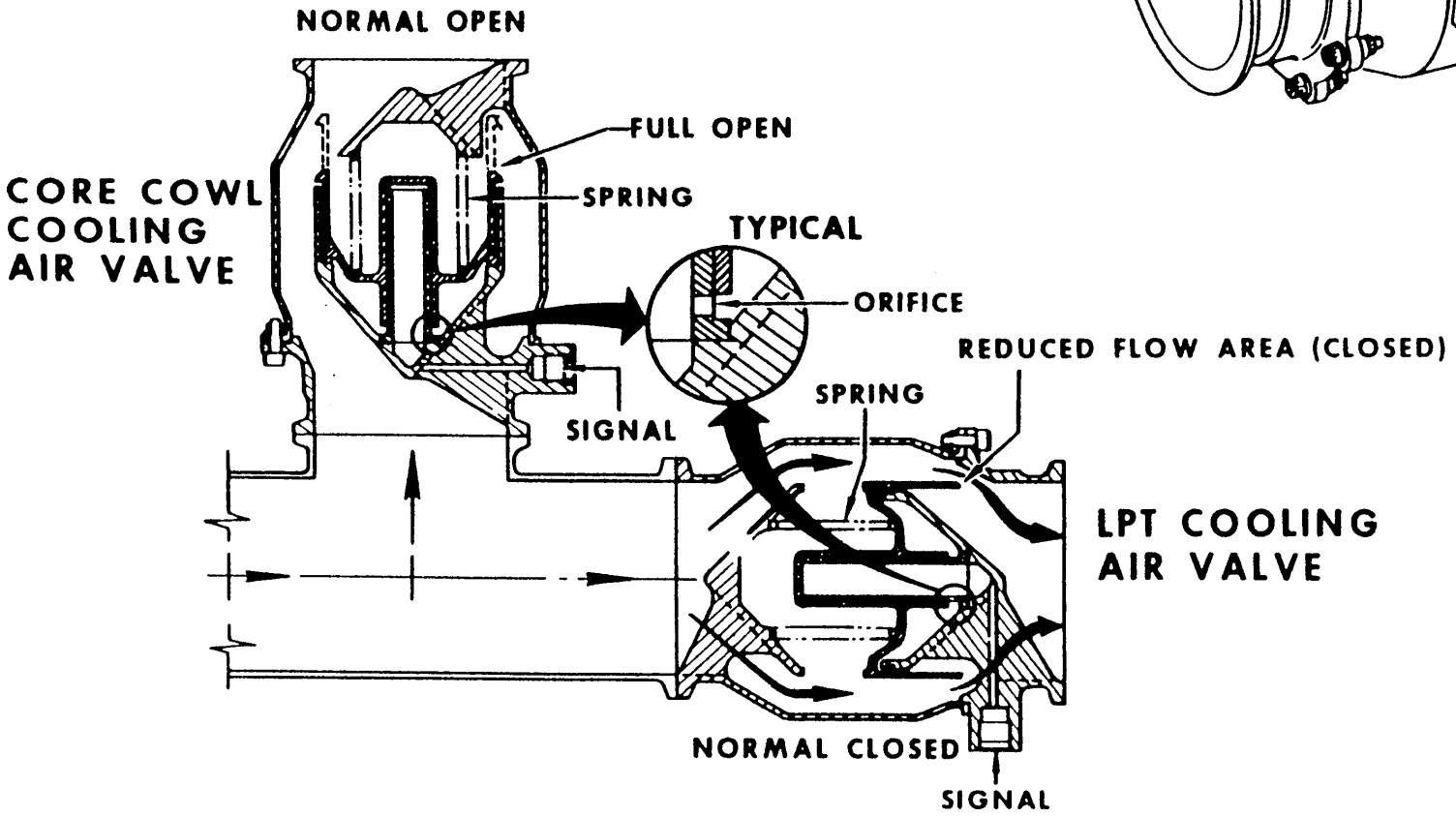
The cooling air valves are of similar external appearance but one is normally open and the other is normally closed or reduced flow area. They are made of aluminum, 3 1/2" duct diameter .

The core cowl cavity cooling air valve is spring loaded open, providing maximum flow at lower altitudes. When the altitude sensor switches above 20,000', it applies a CDP signal to the signal port of the air valve. CDP flowing through the regulator orifice pushes the valve closed against the opposition of the opening spring. The flow area is thereby reduced to the core compartment.

The LPT air valve is spring loaded in the closed direction. The CDP signal introduced above 20,000' to the core cavity cooling air valve is also applied to the LPT air valve through a similar regulator orifice. CDP pressurization of the actuator chamber forces the valve open thereby increasing the cooling flow to the LPT case cooling manifold. The valve at T.O. flows .5pps and at 35,000' cruise it also provides .5pps air flow. The A310 installation uses a valve with an electrical position switch in a circuit of the altitude sensing system to operate a disagree cockpit light.

Cooling Air Valve



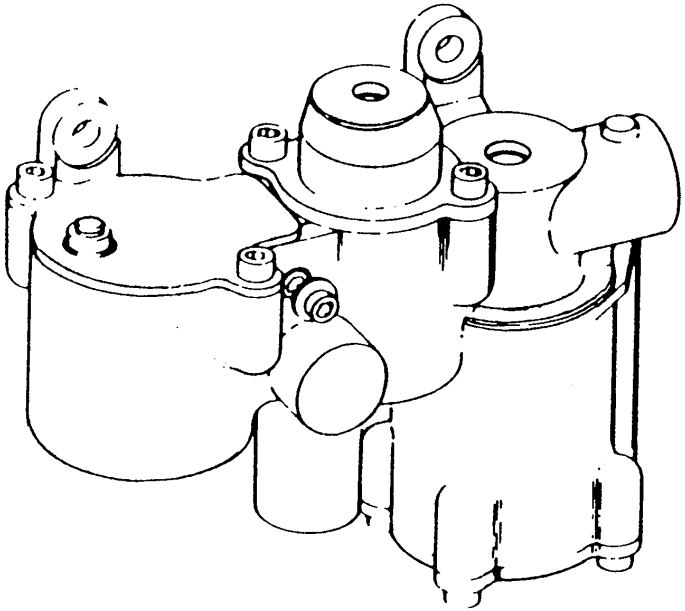


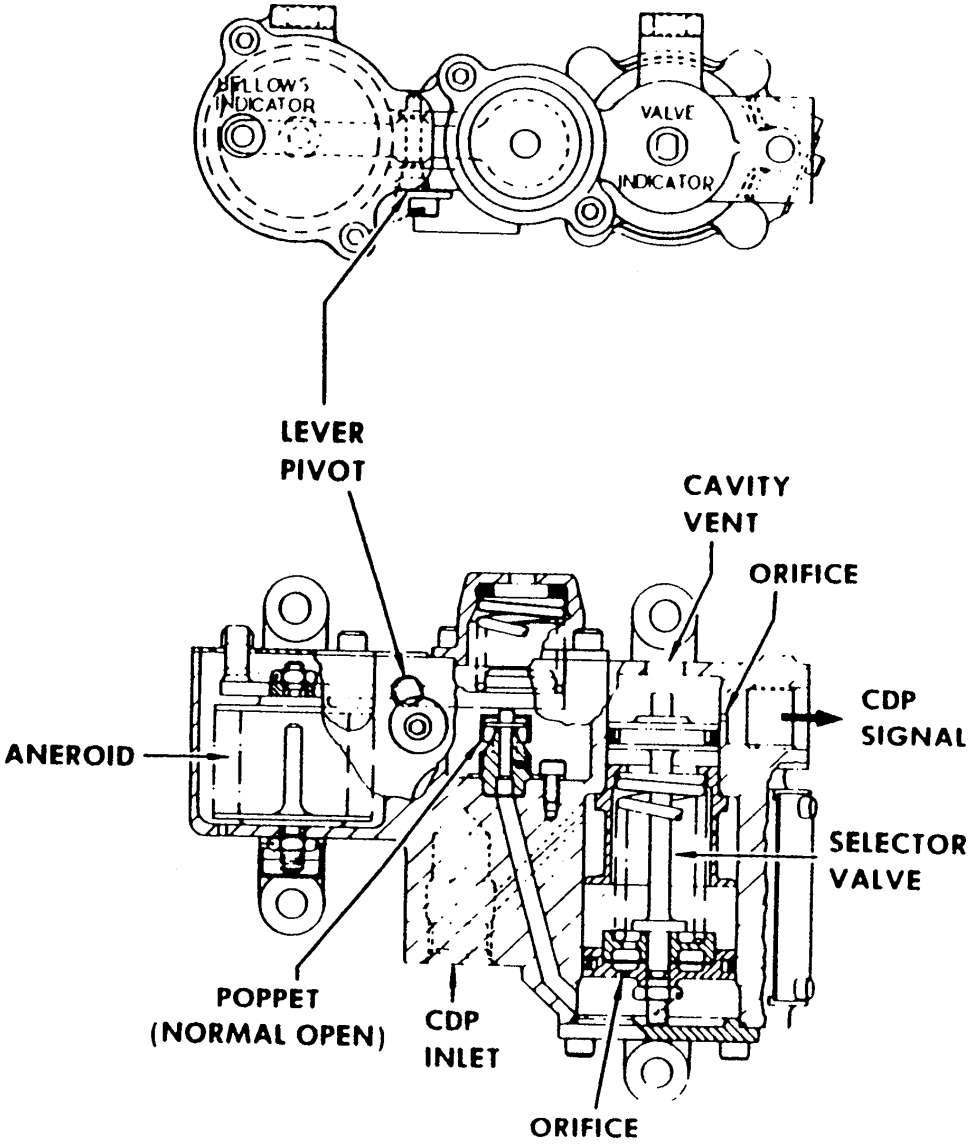
Altitude Sensor

The altitude sensor valve controls the switching signal to the cooling air valves. Compressor discharge pressure is applied to both cooling air valves by a selector valve in the altitude sensor when an aneroid detects altitudes above 20,000’ +/- 4,000". Below this altitude the valve switches to the low altitude position. The CDP source is a port on the CRF at 3 o'clock near the forward flange.The aneroid bellows will expand at high altitude pushing a lever against a poppet valve. At the preset 20,000', the poppet is closed to pressurize the chamber below the smaller piston head of the selector valve. The pressurized piston drives the selector valve upward to its travel limit. The upper piston travel opens a port for CDP flow to the cooling air valves switching them to their opposite position. The aneroid chamber has a fail indicator pin which protrudes above the vent housing if the aneroid bellows has failed. It is observed during ground cowl open inspection.

The selector valve spool also provides a failure indicator pin which is exposed above the housing if the valve is pressurized or stuck open. The valve is bolted to a bracket on the compressor case in the 12:00 o'clock position, about stage 6.

Altitude Sensor





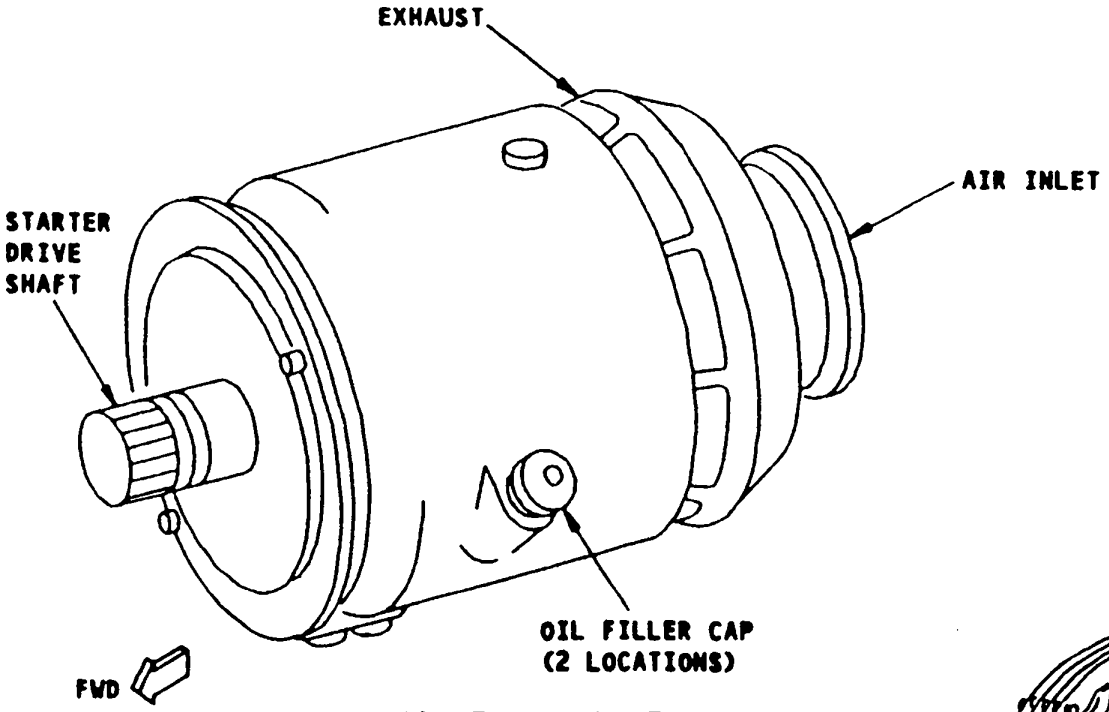
Two vendors have qualified a starter for the CF6-80 engine, Garrett and Hamilton- Standard. The Hamilton-Standard starter employs an adapter ring between its mounting flange and the accessory gearbox mount flange

The starters are single stage air turbines turning through a planetary gear train to reduce the output shaft speed by a factor of 13.5 to 1 on the Garrett model, and at 10.45 to 1 for the Hamilton Standard model.

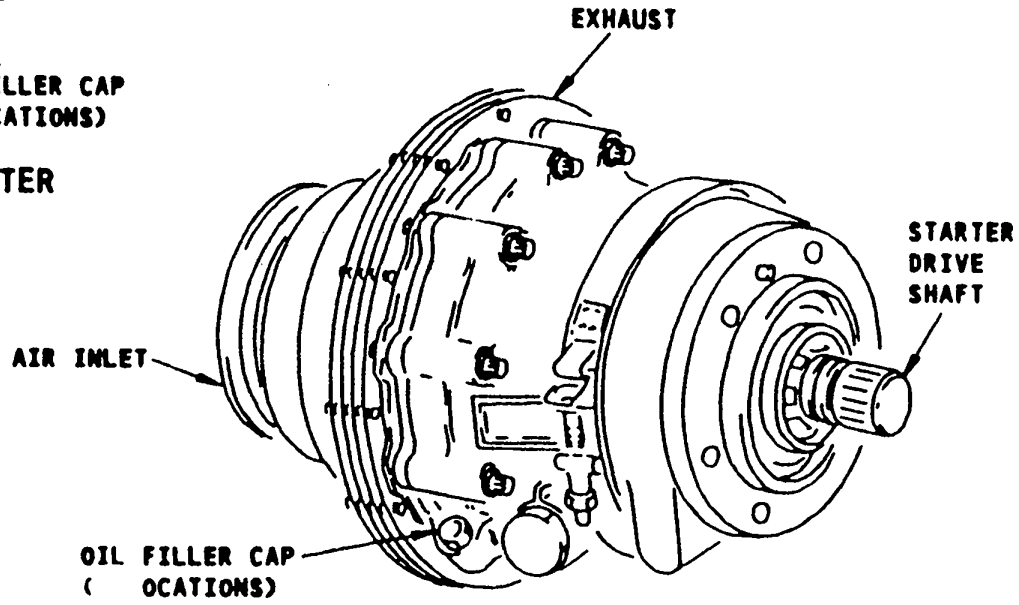
The CF6-BOA1/A3 starter is installed to the fan mounted AGB at 6 o'clock on the forward surface. It also employs the hinged "V" band clamp.

Self contained splash lubrication system. Garrett starter oil capacity is 800 c.c. limited by a stand pipe and overflow port. The Hamilton-Standard starter has a 350 c.c. oil capacity. Two fill ports, one on each side, improve access for service. Drain plug incorporates a permanent magnet check valve. The drain plug housing provides a check valve.

Garrett and Hamilton Standard Starters



GARRETT STARTER

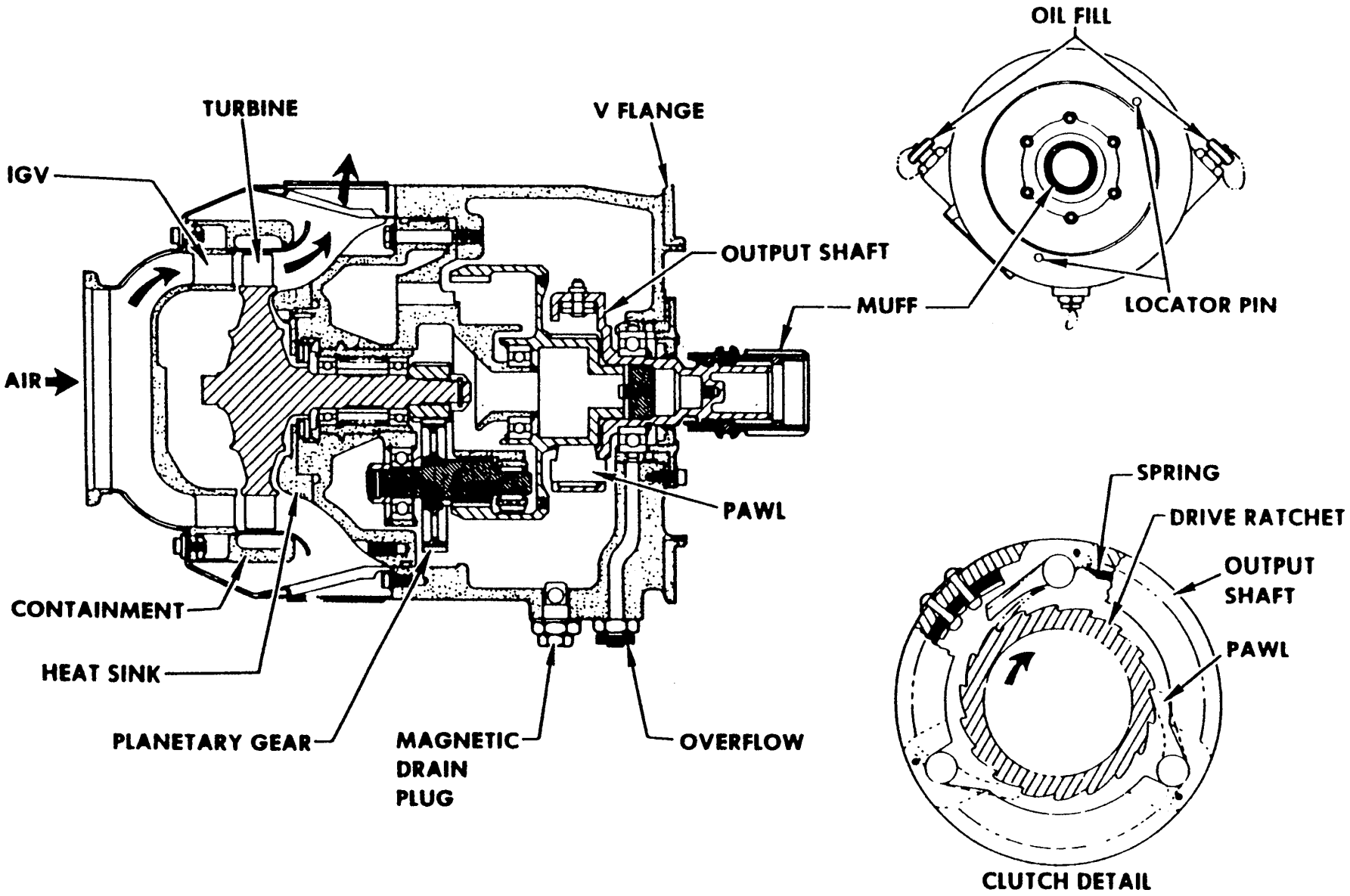


HAMILTON STANDARD STARTER

Starter

The starter is duty cycle limited due to the limitations of the bearings and lube supply.Operating cycle is 5 minutes with 2 minutes cooling. After the first cycle, repeat operation requires a 10 minute cooling period between each cycle. The starter assist to the engine begins at zero N2 when air flow at recommended pressure is initiated. (25-55 psi). Core engine motoring speed maximum 22-26% N2. Engine fuel-on to make a start at 15% N2. Starter centrifugal clutch disconnect capability at 39-40% N2, re-engage at 10% N2.

Starter Section



Starter Control Valve

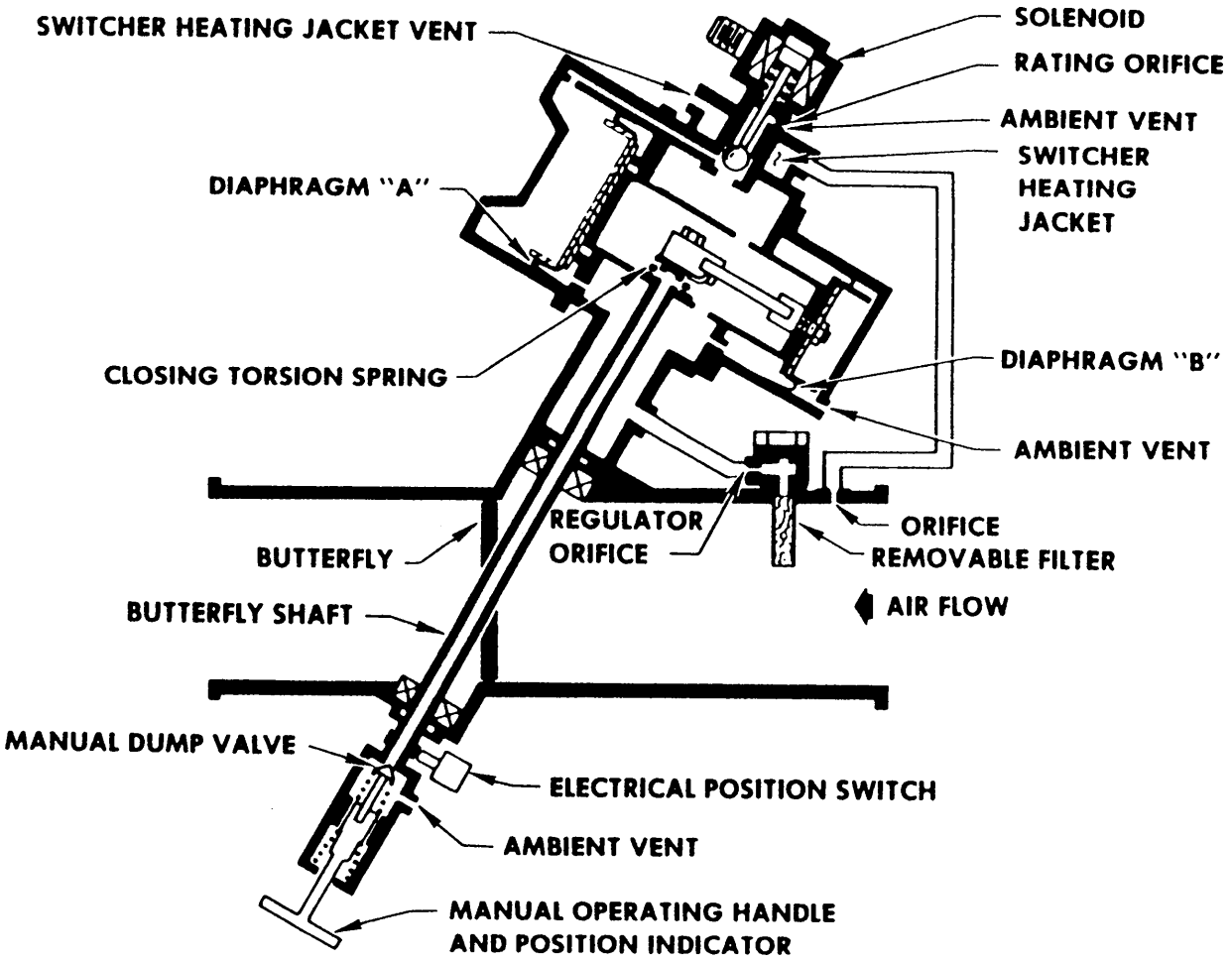
A butterfly valve controls the flow of air to the starter. It has two positions open and closed. Normally operated by pneumatic pressure switched by a solenoid check valve. A manual override "T" handle is provided to open the valve in case of a valve failure.

The valve is installed to a bracket on the inlet cowl at approximately 7 o'clock.

The butterfly valve is fitted to a hollow shaft, which by crank and connecting rod is connected to an unequal sized double diaphragm actuator. The closing force on the shaft is exerted by the closing torsion spring and pneumatic pressure on diaphragm "B" when there is duct pressure. The pressure difference across the larger diaphragm is controlled by the position of the solenoid vent valve. When energized, the ball check valve will seat on the lower port, venting the outer chamber of diaphragm " A " to ambient through the upper port. The larger size of diaphragm "A" will overcome "B" diaphragm and the closing spring forcing the actuator to turn the shaft and butterfly valve to "open".

Manual operation is accomplished by "T" handle movement. It is a two step procedure. The handle must be pulled axially to vent the actuator chambers to ambient, neutralizing the actuator. The actuator chamber pneumatic resupply is limited by the regulator orifice so the "T" handle venting is effective. Then it is necessary to turn the "T" handle clockwise applying enough force to overcome the closing torsion spring. Turn to the open position and hold throughout the motoring period. To close, reverse the steps.

Starter Air Valve

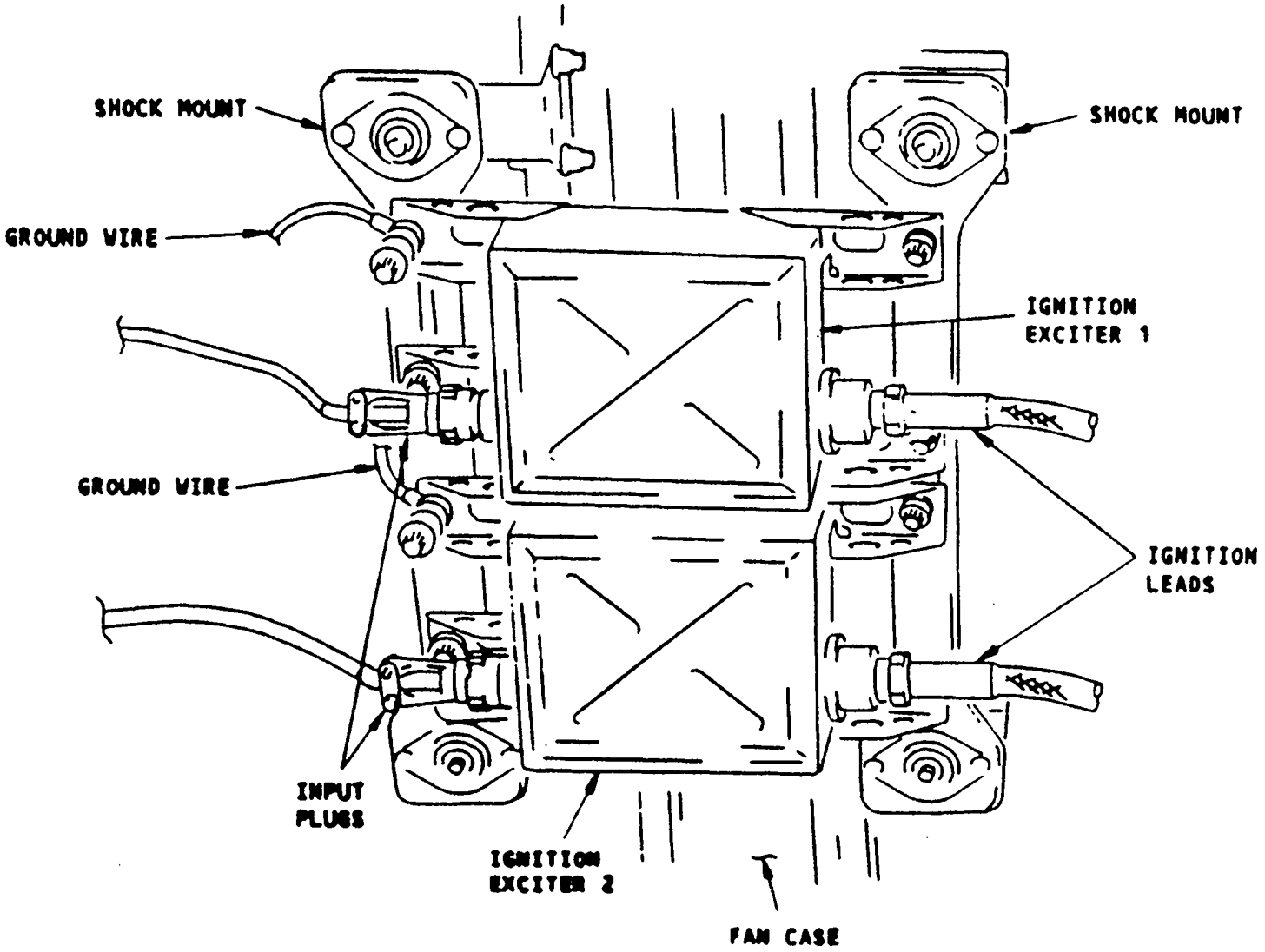


A new low energy ignition exciter with a repetitive discharge spark ignites the fuel in the combustor which ignites a self sustaining flame. They are installed on the fan stator on shock absorbing brackets at the 3:30 position. A soldered aluminum case, grey in color, charged with dry air, encloses the capacitor charging and discharging circuits. The internal components are potted..

Two electrical connectors on opposite ends of the box provide; a power supply input of 110 VAC, 400Hz input, and low voltage output of 1.5 joules per spark with a spark rate of approximately 1 spark/second. The box contains circuit elements to isolate the unit from interference with the aircraft electronics, step up transformers, full wave rectifiers to charge the storage capacitors, and arc gaps which ionize to break down the resistance to discharge the storage capacitors. The high voltage connector has a replaceable gold plated pin deeply recessed within the connector.

The unit is rated for continuous operation.

Ignition Exciters



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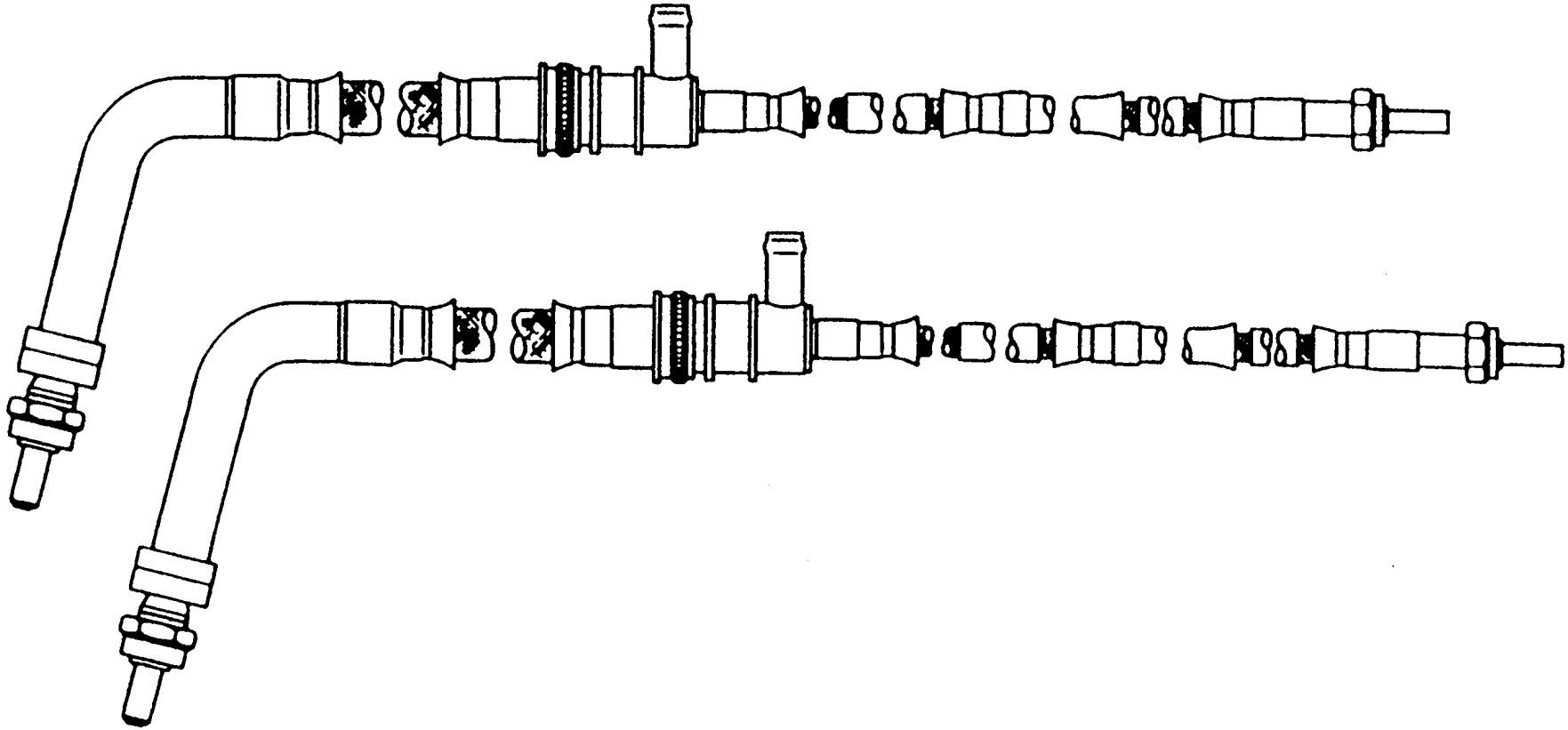
Ignition Leads



Igniter Plugs

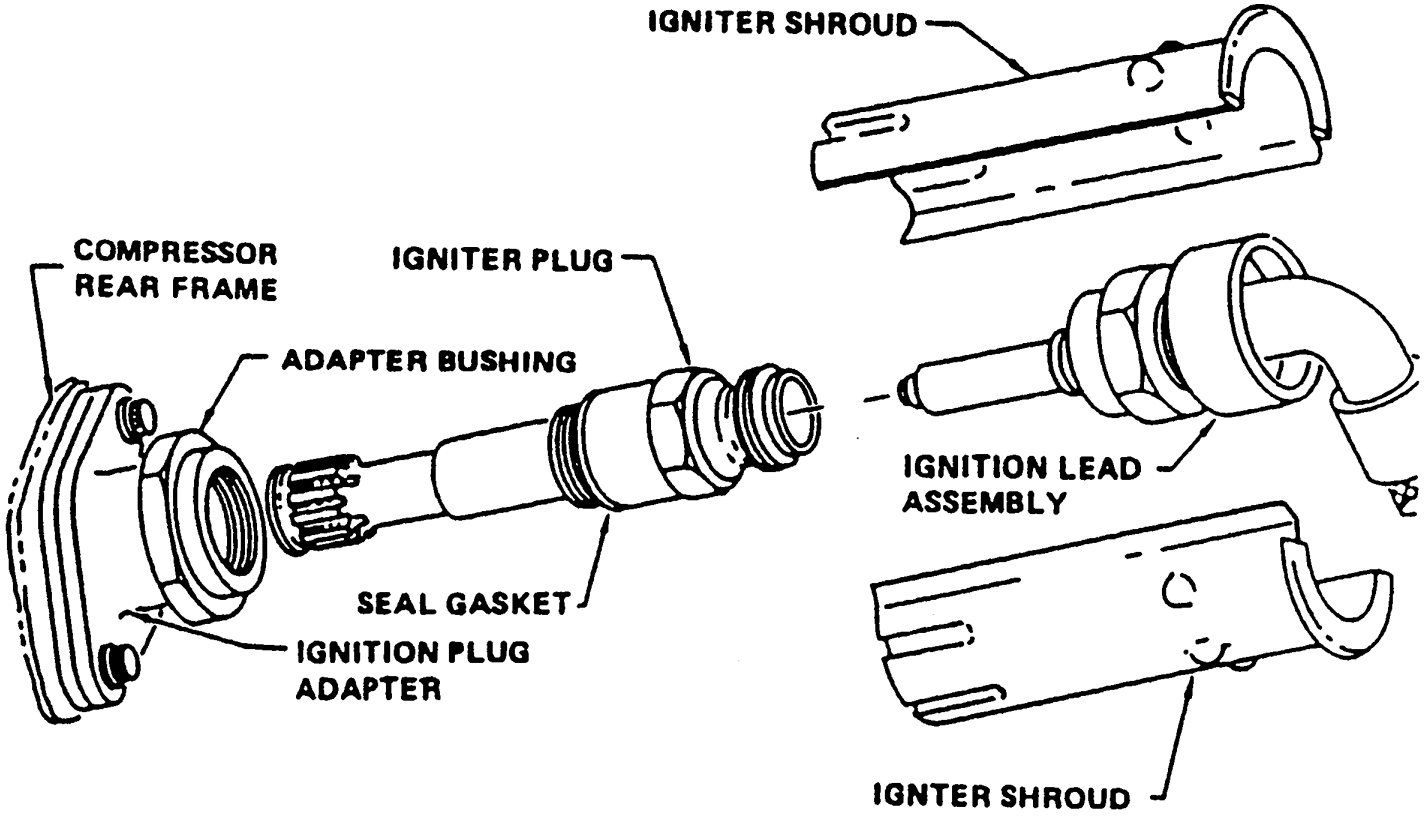
The plug provides a surface gap for the discharge of the high energy of the ignition exciter in order to ignite the fuel in the combustor. The igniter plugs are installed at 3 and 4 o'clock on the compressor rear frame aft of the fuel nozzles. The igniter is a threaded, type 4F, surface gap type design. There are two types available, one having a Beryllium Oxide insulator, and one with a silicone nitrate insulator.

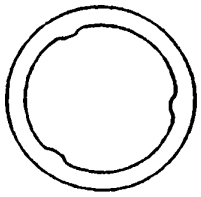
WARNING

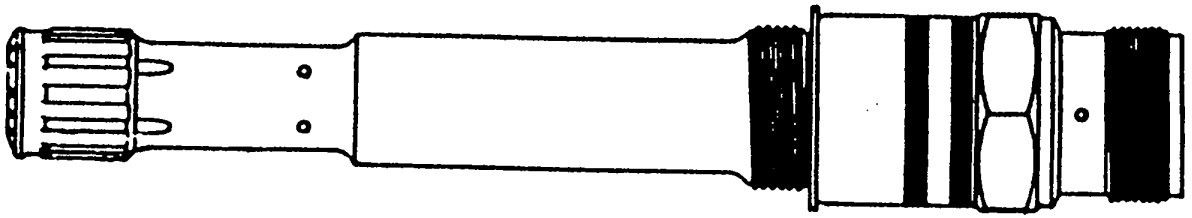
The beryllium oxide plugs require special handling and disposal.

The beryllium plugs are identified by two blue bands around the circumference of the terminal end bushing. The silicone nitrate plug requires no special handling or disposal. Air cooling holes are provided in the ground electrode shell and in the center electrode for maximum cooling efficiency. A convective two-piece cooling schroud is wraped around the installed plug/lead connection. The schroud traps the discharge cooling air from the aft lead and directs the air down over the surface of the plug, thus helping to cool the igniter and increase life. The cooling air exits the schroud adjacent to the threaded coupling on the compressor rear frame. The schroud also ensures that the silicone seal in the terminal end remains below 450 deg. F (230 deg. C)

Igniter Plug



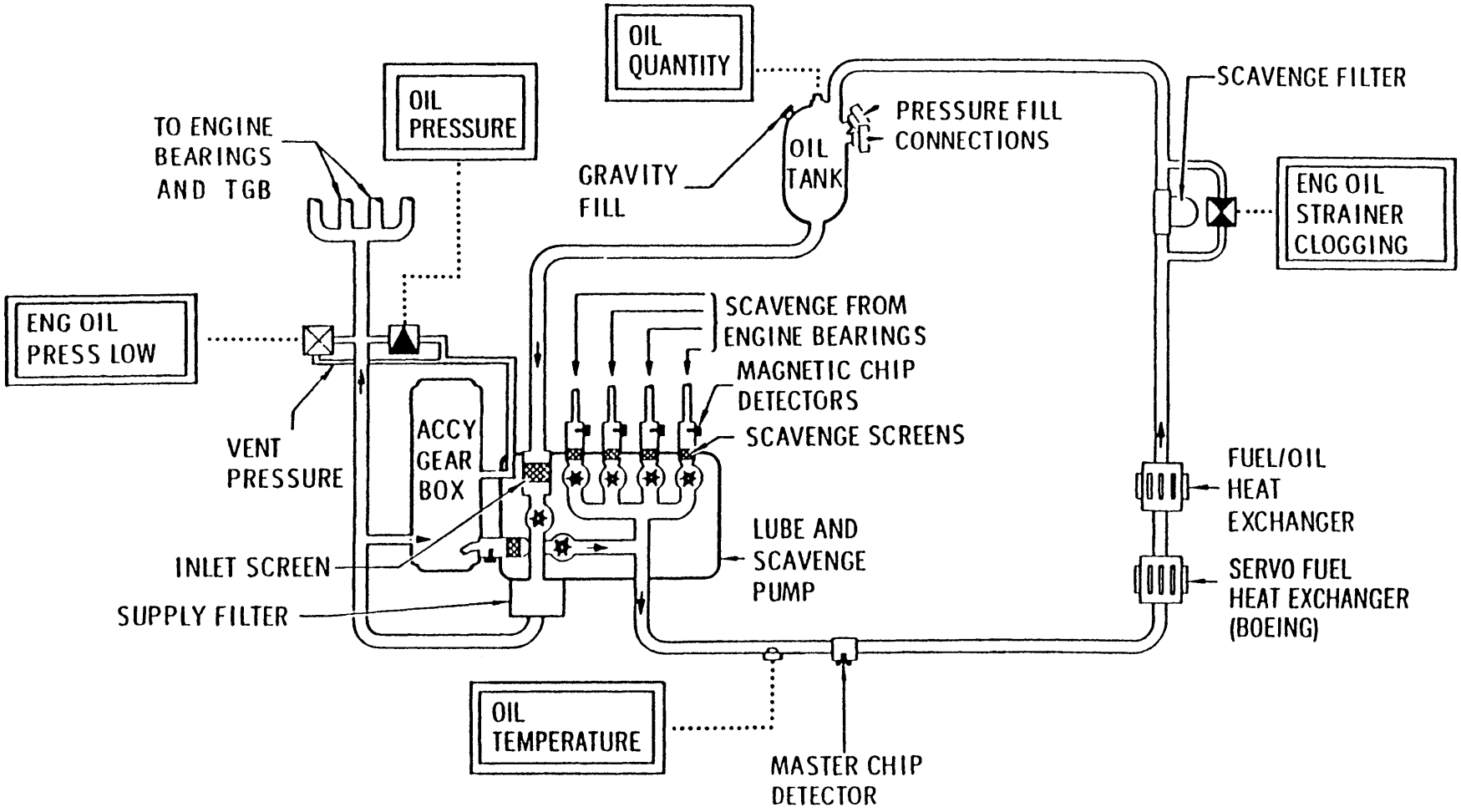




The CF6 oil system is a non-regulated type system, meaning that the system does not have an oil pressure relief valve to maintain oil pressure at a steady value regardless of engine RPM. The oil pressure of a CF6 engine "follows the throttle" and is variable given different ambient conditions. Pressure in the system is determined by the pumping capacity verses the restriction of the passage of the oil through the nozzles. With this type of oil system, the operator can quickly determine the ability of the system to deliver the correct volume of oil to each part of the engine.

The central lube and scavenge pump has one pressure element for the entire engine. Separate scavenge elements remove oil from each engine cavity/component and return the oil to the tank in one common scavenge discharge line. In route to the tank the scavenge oil passes a temperature sensor, a magnetic chip detector and lastly the fuel-oil heat exchanger. The nominal flow rate of the oil is 16.75 gallons per minute (gpm) (63.4 liters). A 46 micron supply filter and a 15 micron scavenge filter are used. The engine will function satisfactorily with oil conforming to GE Specification No. D50TF1, Class A or Class B. Oils conforming to MIL-L-7808 and MIL-L-23699A are consistent with this GE specification. Oil consumption rate is expected to be approximately 0.07 gph = 0.26 liter with maximum rate set at 0.2 g/h 0.76 liter, providing an estimated flight length of 16 hours.

Engine Oil System Functional



Oil Tank

This oil tank is the same as the CF6-6/-50/-45 engine. It is a cylindrical aluminum fabrication with spherical domes. The tank is installed to the fan stator at 4 o'clock by a shock absorbing system. The tank is supported by two mounting rings. The rings are hinge bolted to the fan stator brackets at the top. Two spring loaded turnbuckles, at the lower clevises, pull the mounting rings against center braces. Rubberized fabric pads reduce fretting at the center braces. The tank volume is 31.6 quarts U.S., 24 quarts is oil, the balance is pressurizing air volume. The low oil level is indicated by either a dipstick on the filler cap or by a magnetic float type sensor installed to a flanged port on the upper housing. Ports on the tank provide for:

Oil Fill

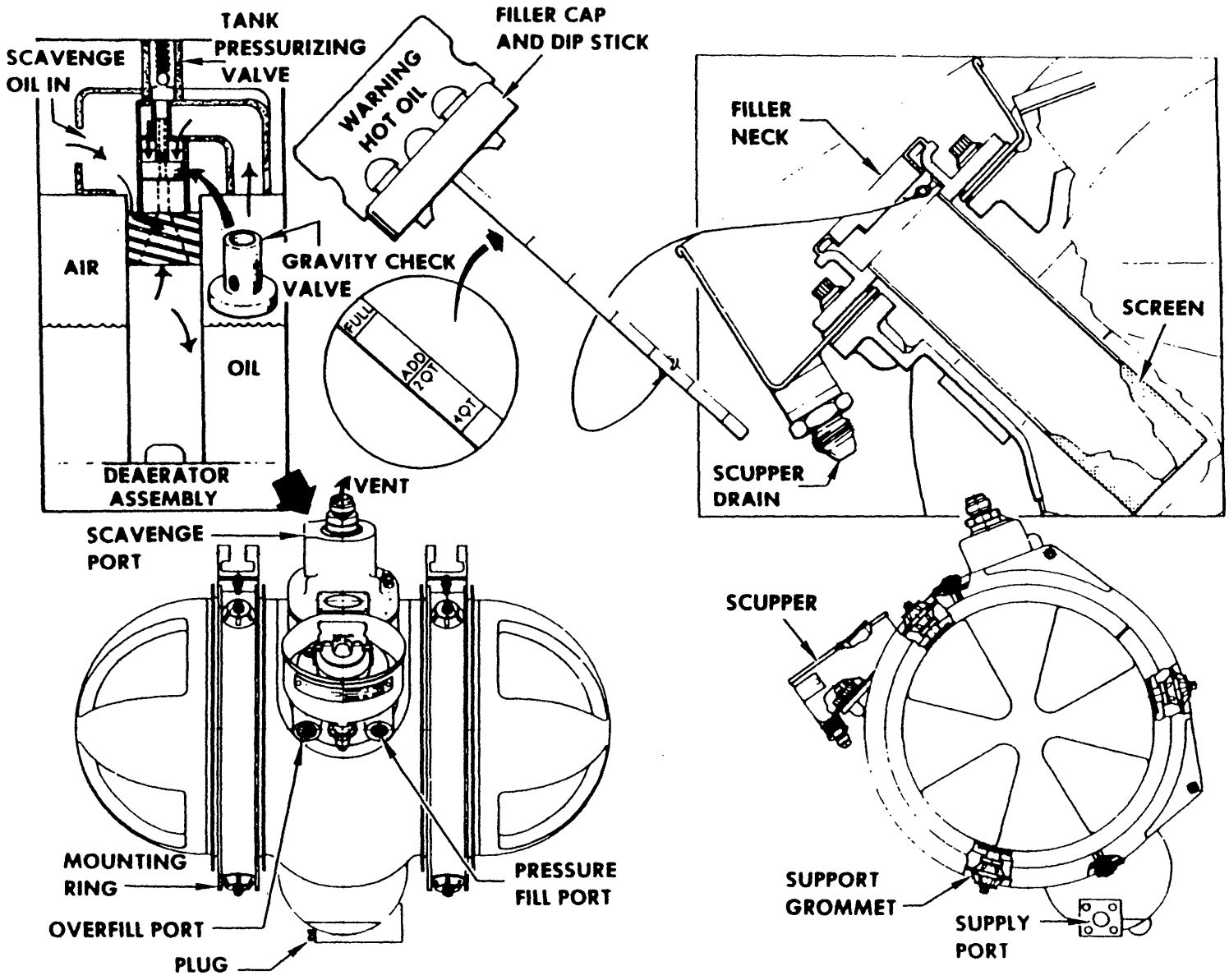
Manual fill. A spring loaded, lever type handle turns the filler cap to remove it. A relief valve is incorporated in the cap. It relieves at 35 psid and reseats at 23 psid.

Pressure fill and overfill ports are provided for connection to a service cart.

Oil supply out a flanged port at the bottom of the tank.

Drain plug is along side the supply port. Scavenge oil inlet power is a flanged type on the side of the upper housing. Vent port is a threaded boss to receive the pressurizing valve. The pressurizing valve maintains 7-9 psid pressure in the tank. The pressure bleeds off to the "A" sump through a vent manifold routed over the fan case to strut #11 of the fan frame. Complete venting of the tank will occur approximately 5 minutes after engine shutdown. Air-oil separation is accomplished by a vaned vortex generator that receives the incoming scavenge air-oil. The oil swirls through the vortex generator and against the sides of the tube to breakup the oil bubbles. The air vents out the top through the pressurizing valve.

Oil Tank


TANK PRESSURIZING VALVE
SCAVENGE OIL IN
FILLER CAP AND DIP STICK
WARNING HOT OIL
AIR
GRAVITY CHECK VALVE
FULL
ADD 2QT
4QT
OIL
DEAERATOR ASSEMBLY
VENT
FILLER NECK
SCREEN
SCUPPER DRAIN
SCAVENGE PORT
SCUPPER
MOUNTING RING
PRESSURE FILL PORT
OVERFILL PORT
PLUG
SUPPORT GROMMET
SUPPLY PORT

Oil System

The lube and scavenge pump provides pressurized filtered oil to the supply manifold, and removes oil from the sump to recirculate It. Two pumps are certified. The newer pump uses the same casting but deletes the inlet screen port, extension drive shaft and carbon seal with drain and cold start relief valve.

Mounted to the forward face of Accessory Gearbox at 6:30 o'clock by "V" band clamp, safety wired.

- Lubricated spline drive.
- Shear section 1500-2000 in lb.

Positive displacement vane type pump with one element for supply and five elements for separate scavenge areas.

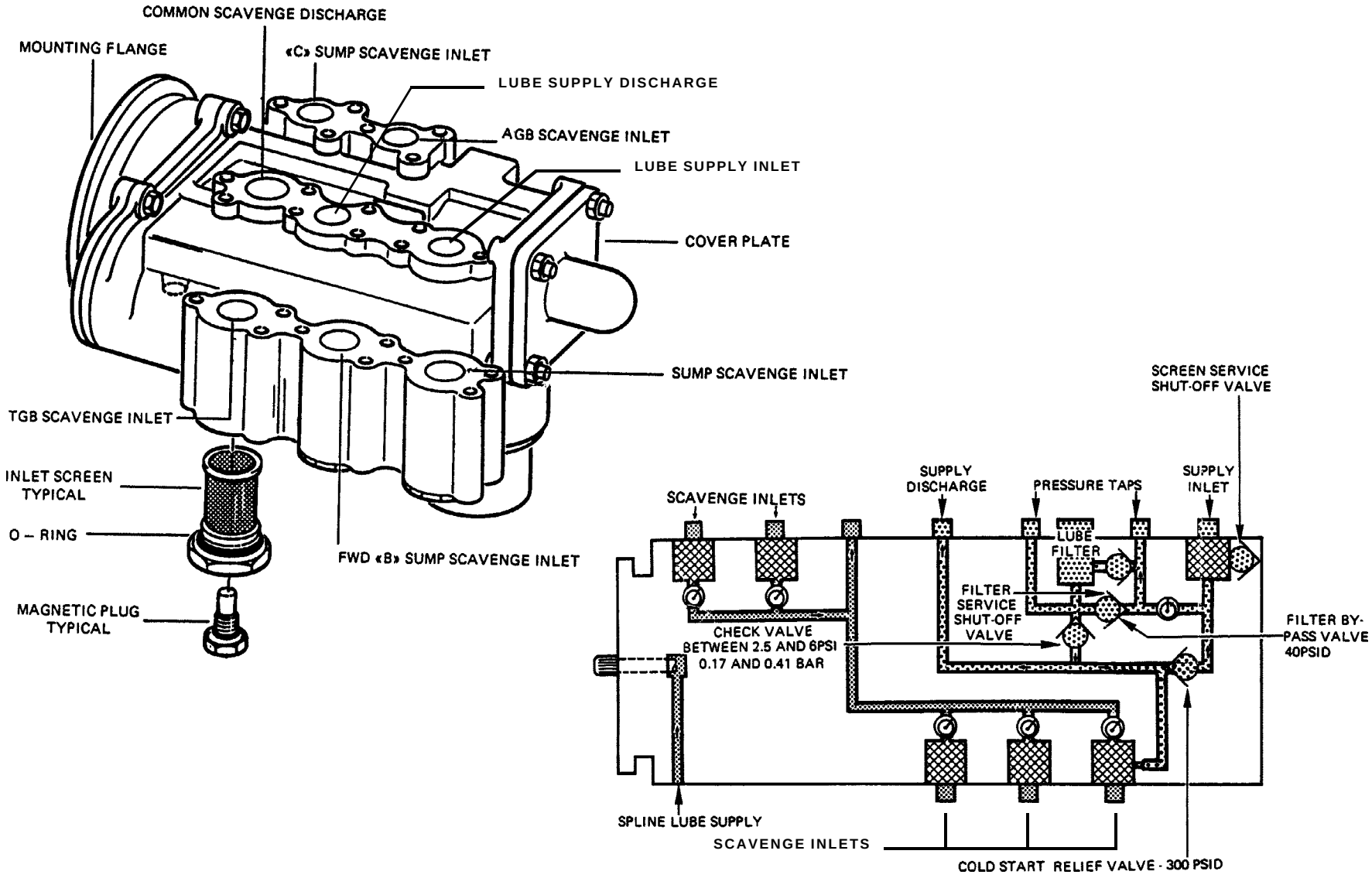
Inlet screens, 26 mesh, at every inlet contain permanent magnetic chip detector plugs, except the supply inlet screen.

- "B" element oil injection -bleed oil supply to aft "B" sump finger screen plug from supply filter discharge pressure port. Keeps "B" pump element wet to maintain pumping capability to avoid excessive gulping indications and oil loss at aft "B" sump drain.

Bypass, relief, and check valves provided for:

- Inlet screen removal, oil supply port.
- Filter removal.
- Filter bypass 40-50 psid, F.O. 70 psid
- Cold start relief for pressure transducer at 300 psid, F.O. 400 paid reseats at 275 psid
- Anti - static leak at 2.5 to 6 psid

Lube and Scavenge Pump



Sump Pump Element

Supply pump element

Inlet pressure head of 8.5 to 10.5 psi.

Output of 16.75 gpm at 70 psia.

Supply filter is a 46 micron, cleanable, metal. No bypass indication is furnished, 40 psid. It is the secondary filter in the lube system.

Five separate scavenge return ports. Scavenge pump elements remove an air-oil mixture developing 85 psid at 100% N2 in common scavenge discharge.

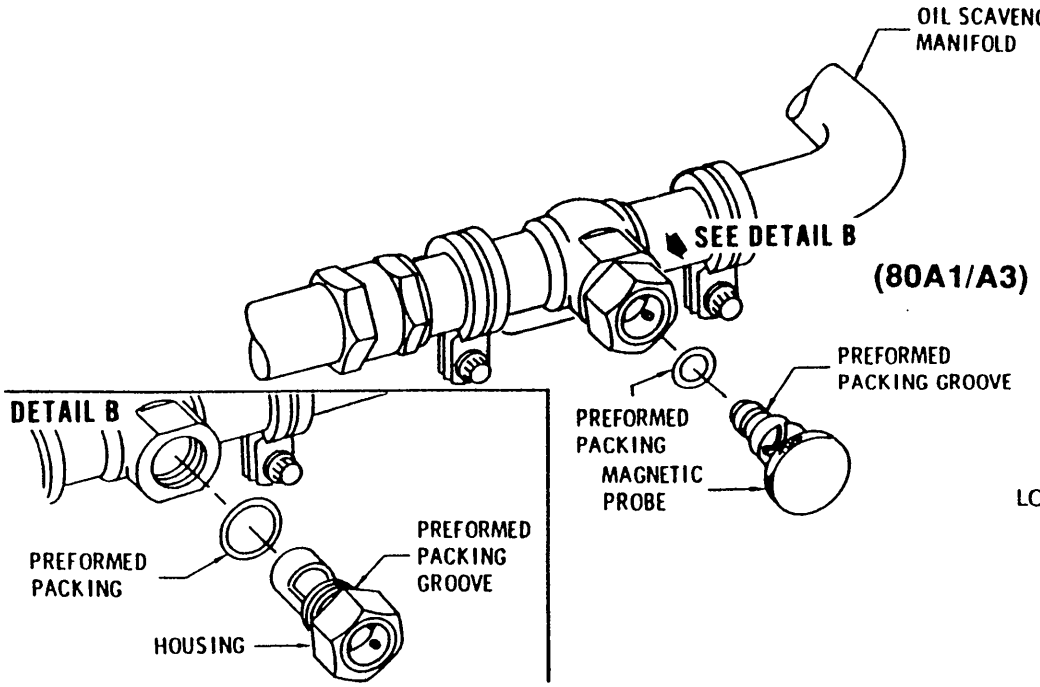
A pump designed specifically for the 80 engine will eliminate the front drive spline used for speed indication on the -50 and the cold start relief valve. It also removes the supply inlet screen service shut-off valve and eliminates the threaded plug associated with the inlet screen, however, the screen will be maintained.

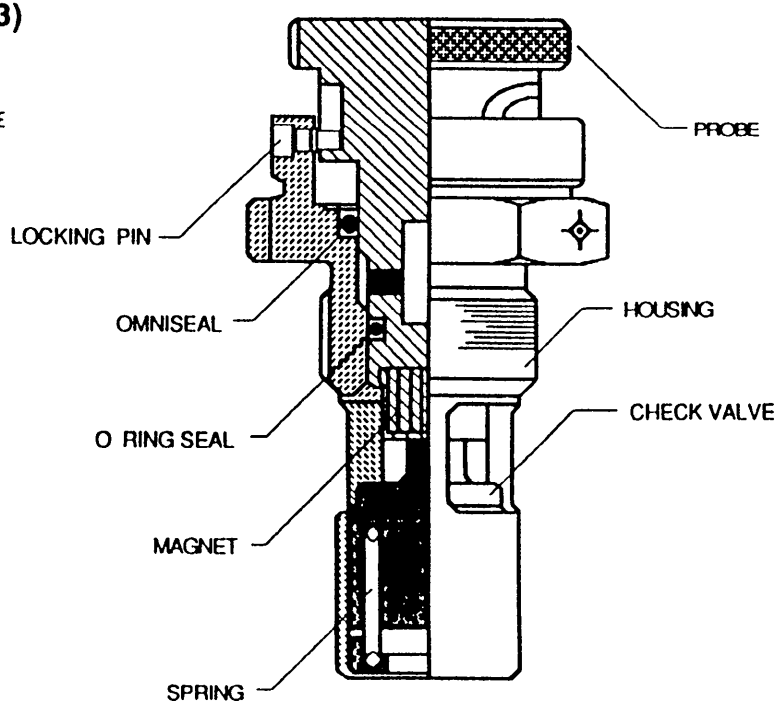
Sump Pump Element

Master Magnetic Chip Detector

The permanent magnet is able to attract bearing particles carried in the scavenge oil. By frequent inspection, early detection of bearing failure should be possible. The actual bearing at fault must be identified by a magnet and screen check of the L & S pump to isolate the sump with the problem. The magnet is located in the common scavenge line between the L & S pump and the scavenge filter. A permanent magnet is attached to a round, knurled knob for removal. The probe is retained by a bayonet-type, over-center locking connection into a housing containing a check valve to prevent oil loss at removal.

Master Chip Detector





Scavenge Oil Filter

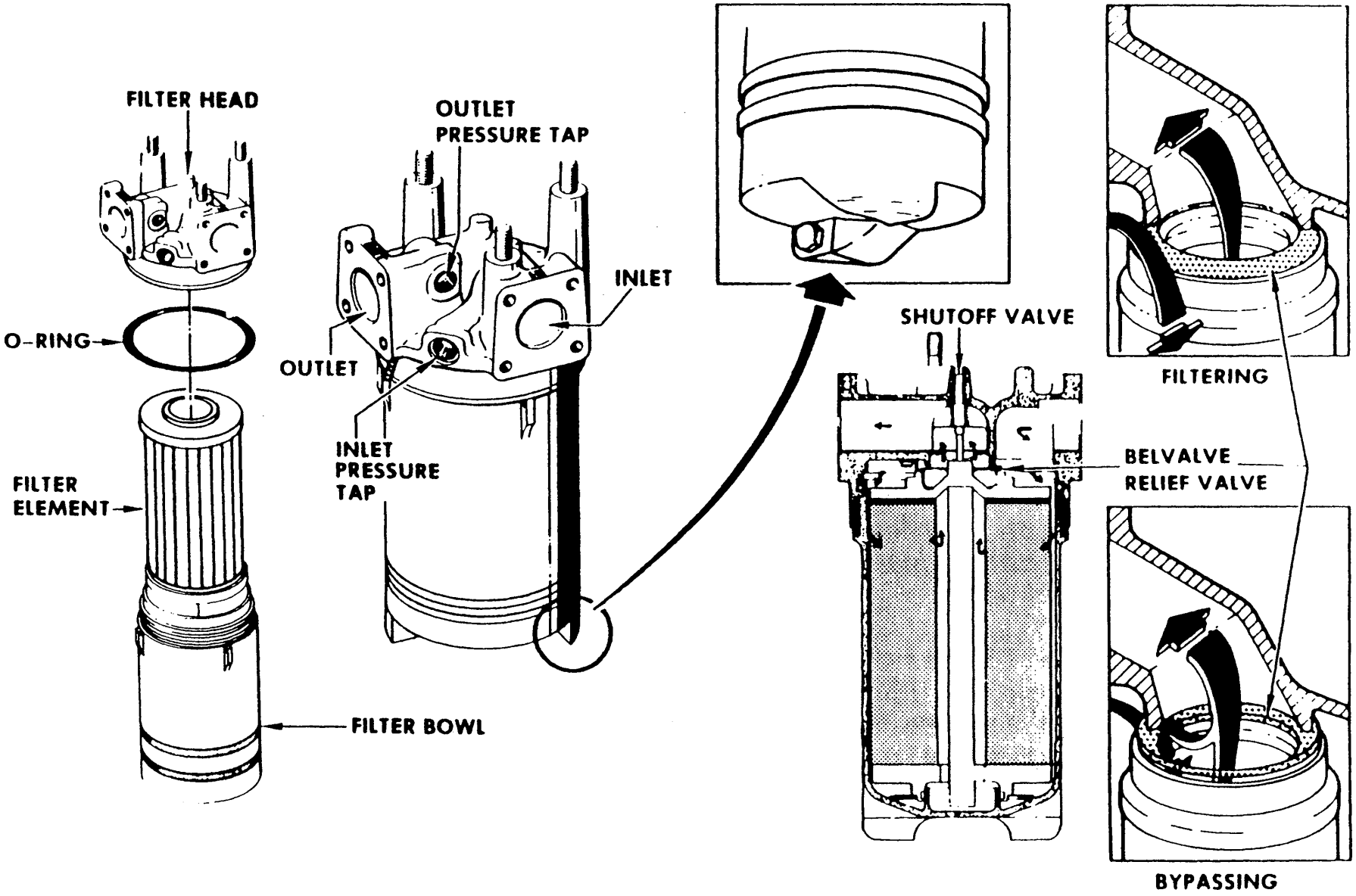
Provides the capability to remove particles larger than 15 micron from the scavenge oil. If clogged there is a bypass relief valve to continue full flow of oil around the filter element. The filter is mounted to a bracket bolted to the aft left side of the AGB.

Filter head contains inlet and discharge ports, pressure differential ports to indicate filter clogging when attached to a differential pressure switch, a filter removal shutoff valve and the filter bypass relief valve. The head also provides a grooved recess for the filter bowl sealing "0" ring, and an anchor screw for lockwire.

The filter bowl contains a boss to center the filter element, the "0" ring sealing surface on the open lip, and the threads for engagement to the head. An external boss provides a shoulder by which a screwdriver shank can apply removal torque. Some customers have purchased a filter bowl without the removal wrenching feature. A strap wrench may be needed to remove that type bowl.

The filter element is a disposable pleated type of 15 micron. The element is reversible. It is a polyester media supported by an inner and outer layer of screen wire. End caps are cemented to the screen wire supports.

Scavenge Oil Filter



Accelerometer

The accelerometer is a rugged device, no moving parts, using piezoelectric crystals and an inertial mass to produce an electrical change in the charge level between two conductors proportional to the severity of vibration. The primary accelerometer is on the No.1 bearing support housing within the A sump. The lead connector is on the fan frame at strut No.5 in the core engine compartment.

Life expected to be 10,000 hours or better

Low signal strength requires specially shielded leads securely supported to avoid and prevent externally induced signals.

Signal conditioner (charge amplifier) required to process signal to usable strength for meter display.

Highly directional, sensitive only parallel to axis of assembly screw.

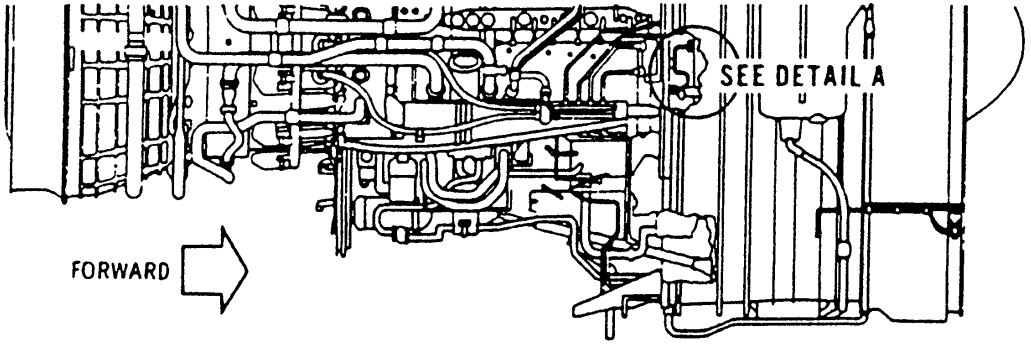
Inertial mass alternately squeezes and releases pressure on wafers of piezoelectric materials in phase with rotor imbalance or vibration.

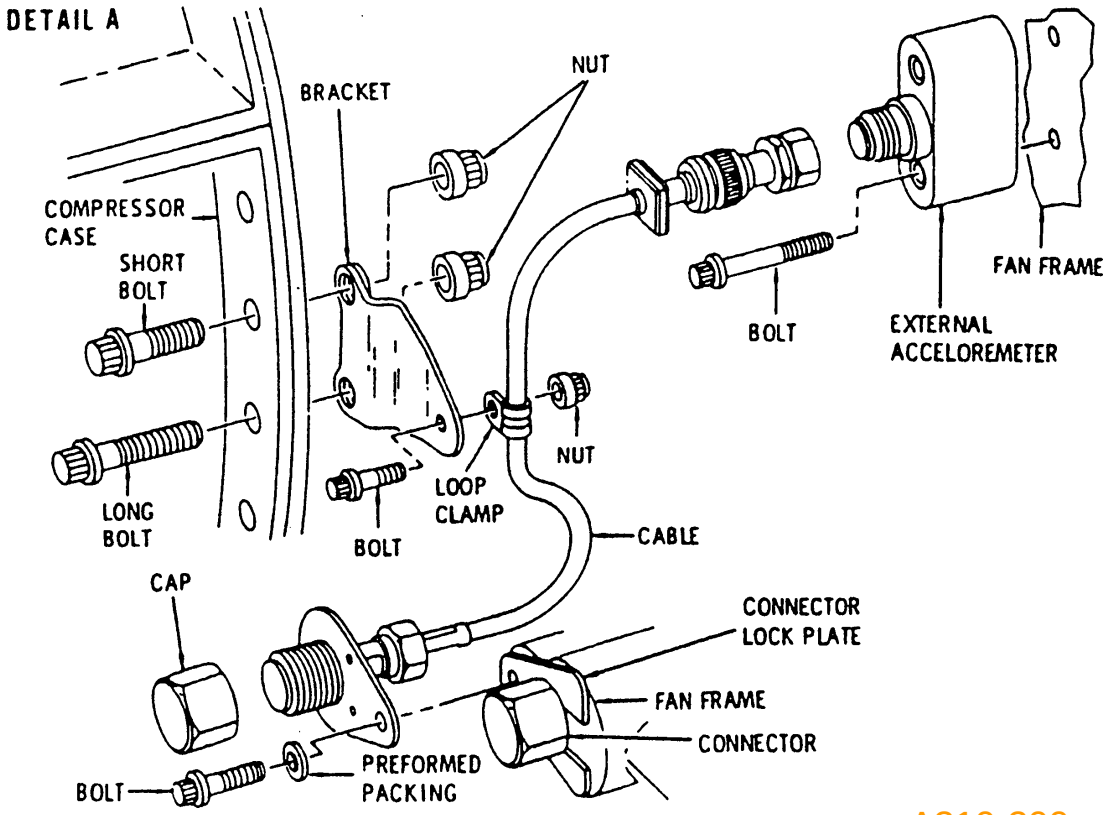
Collectors receive electrical charges produced by piezoelectrical crystals. Alternate layers connect to opposite leads. Output level or charge level so low it is difficult to consider it a current.

Alternate N1 accelerometer

An alternate accelerometer can be mounted to special purpose pad on the fan frame below the 3:00. The alternate N1 accelerometer.has a sensitivity of 125 pc/g.

Alternate N1 Accelerometer





N2 Accelerometer

The N2 vibration sensing accelerometer is mounted on the forward side of the flange between the Compressor Rear Frame and the Compressor Stator Case, at 10:00. It is mounted to a bracket externally and is connected by a hard lead to the junction connector .

Low signal strength requires specially shielded leads securely supported to avoid and prevent externally induced signals.

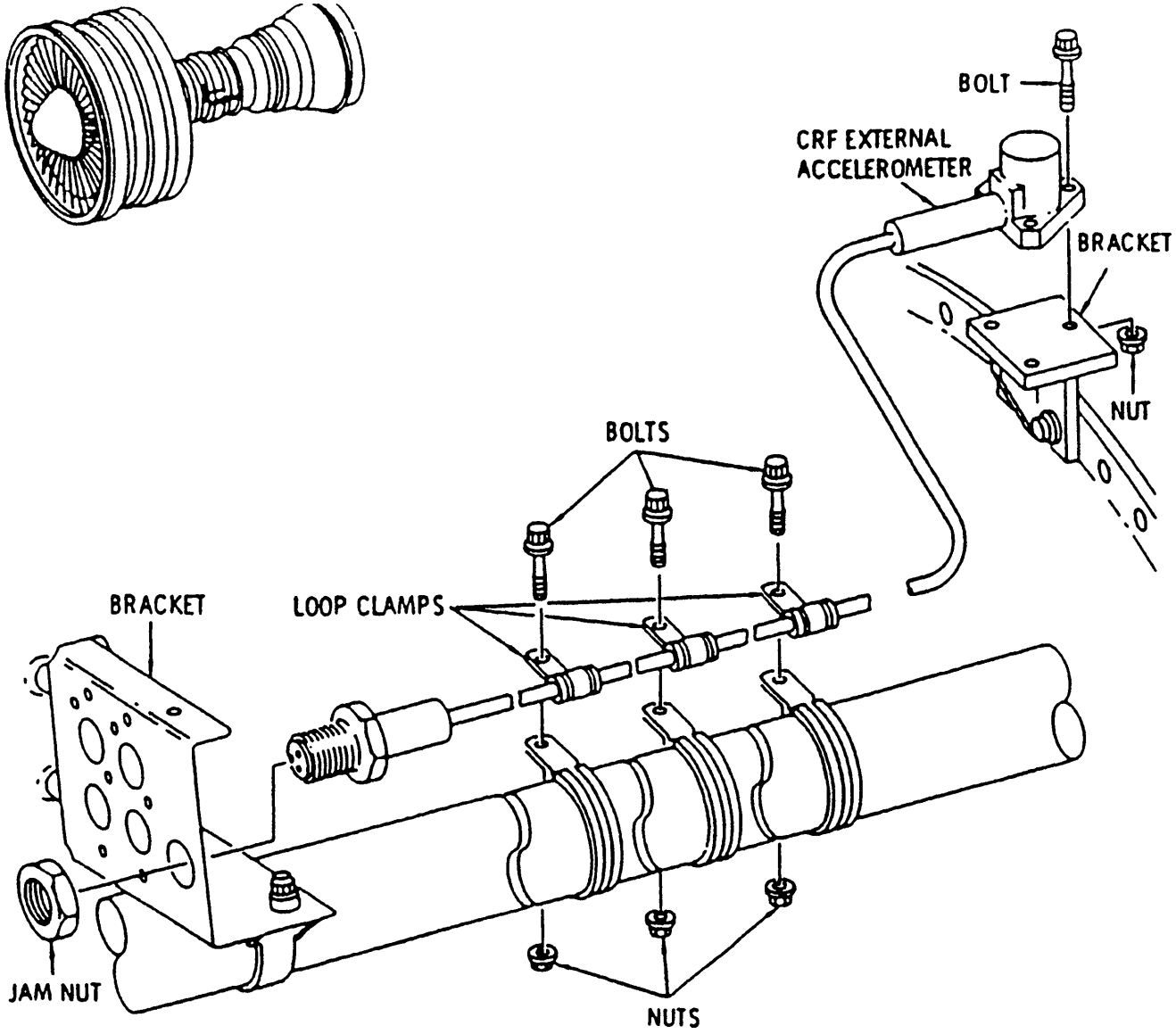
Signal conditioner (charge amplifier) required to process signal to usable strength for meter display.

Highly directional, sensitive only parallel to axis of assembly screw.

Inertial mass alternately squeezes and releases pressure on wafers of piezoelectric materials in phase with rotor imbalance or vibration.

Collectors receive electrical charges produced by piezoelectrical crystals. Alternate layers connect to opposite leads. Output level or charge level so low it is difficult to consider it a current.

N2 Accelerometer



Compressor Inlet Temperature/Pressure (P/T2.5)

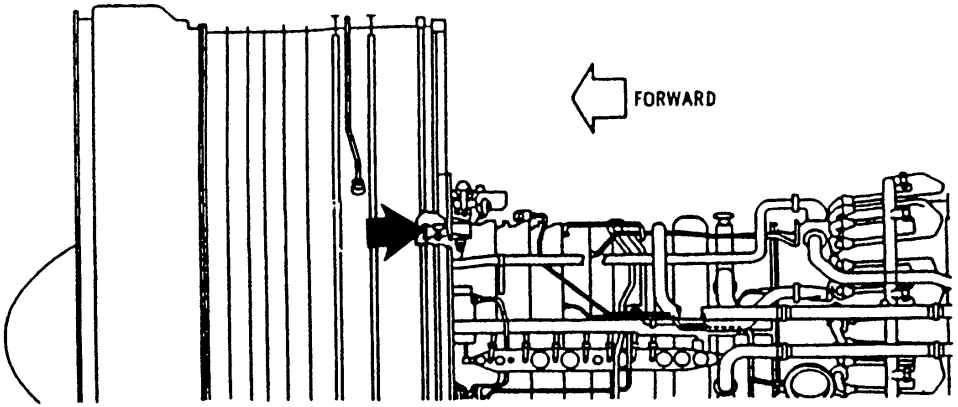
The compressor inlet temperature sensor senses both pressure and temperature within the same housing.

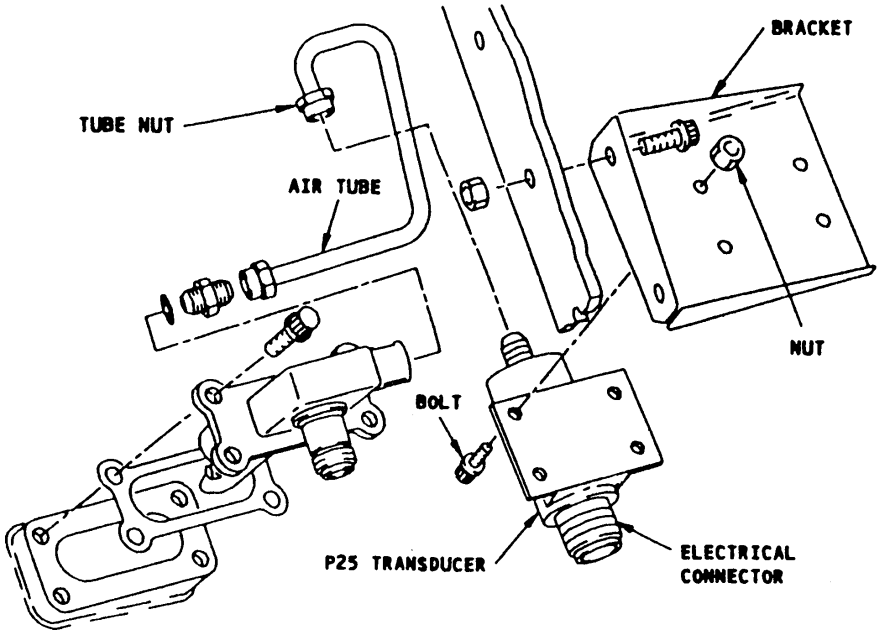
Incorporates a direct Pt pressure probe inserted into the airstream along with a chromel/constant thermocouple

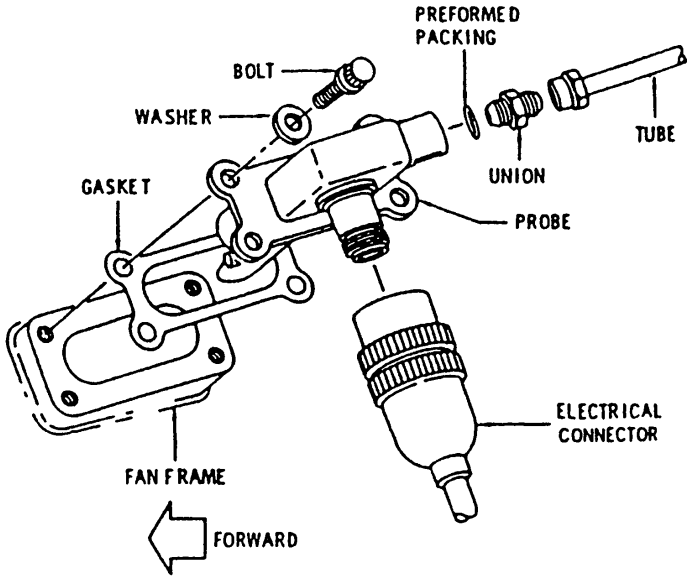
The electrical temperature output is provided to an integral electrical connector on the body of the probe.

The pneumatic output is provided through a threaded port on the body of the probe.

Compressor Inlet Temperature/Pressure Sensor (P/T2.5)







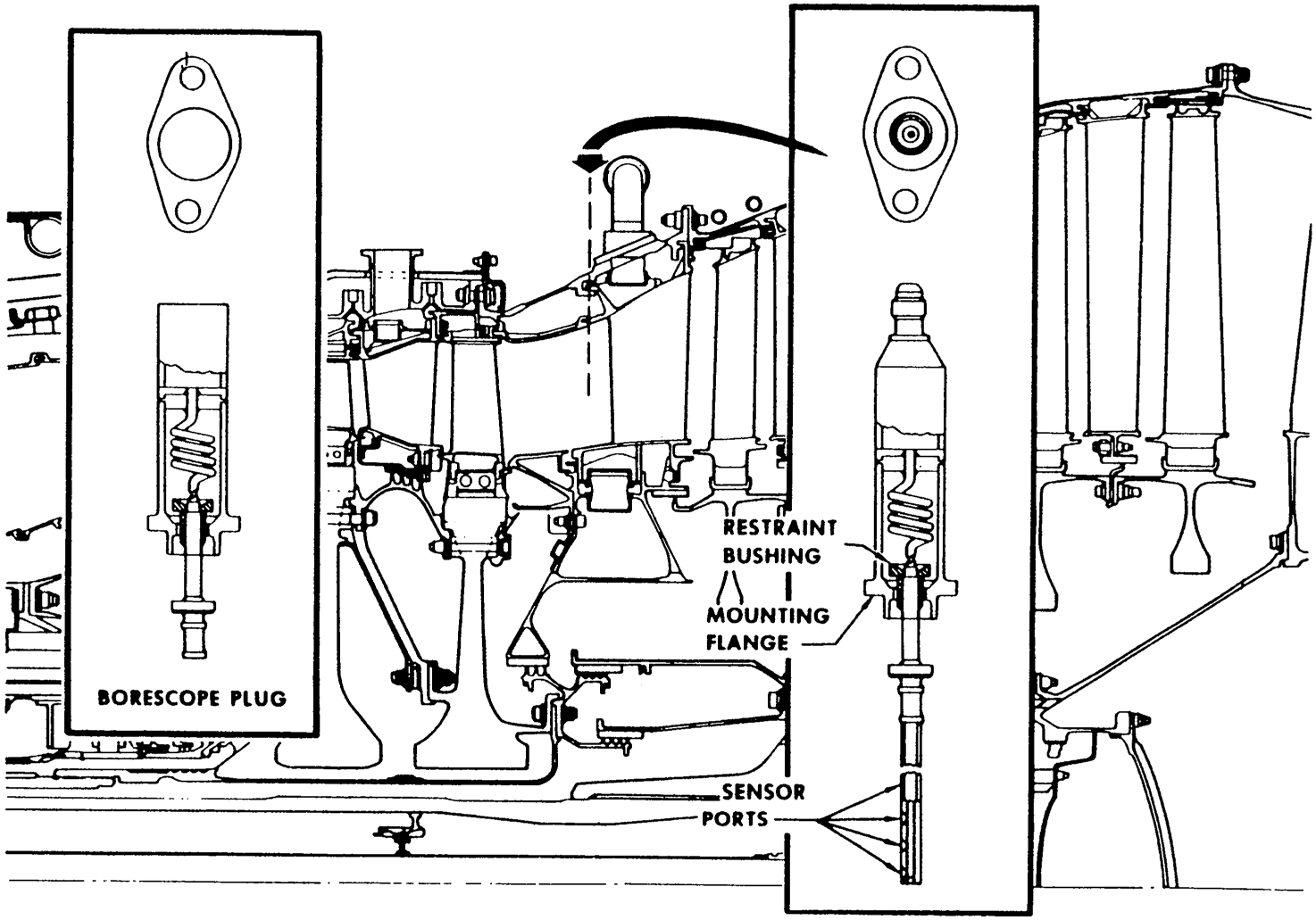
Low Pressure Turbine Inlet Pressure (P4.9)

Pressure obtained from the inlet to the low pressure turbine is used to provide a parameter to help determine the power performance of the core engine. P4.9 pressure can be compared to compressor inlet pressure (P2.5) to develop a value of Engine Pressure Ratio (EPR).

The single probe is installed into a boss on the LPT 1st stage turbine nozzle case. There are three available bosses for this purpose. Generally the probe is installed at the 3:30 position, with the bosses at 4:00 and 1:00 plugged. These two additional ports can be used for borescope inspection and as additional positions to measure total pressure at engine test.

On the probe stem there are four inlet ports directed toward the gas flow. The mounting flange has two bolt holes located off the center line to assure the ports are correctly oriented. The probe stem enters the outer housing containing the coiled manifold, which absorbs vibration and withstands the thermal expansion and removal forces.

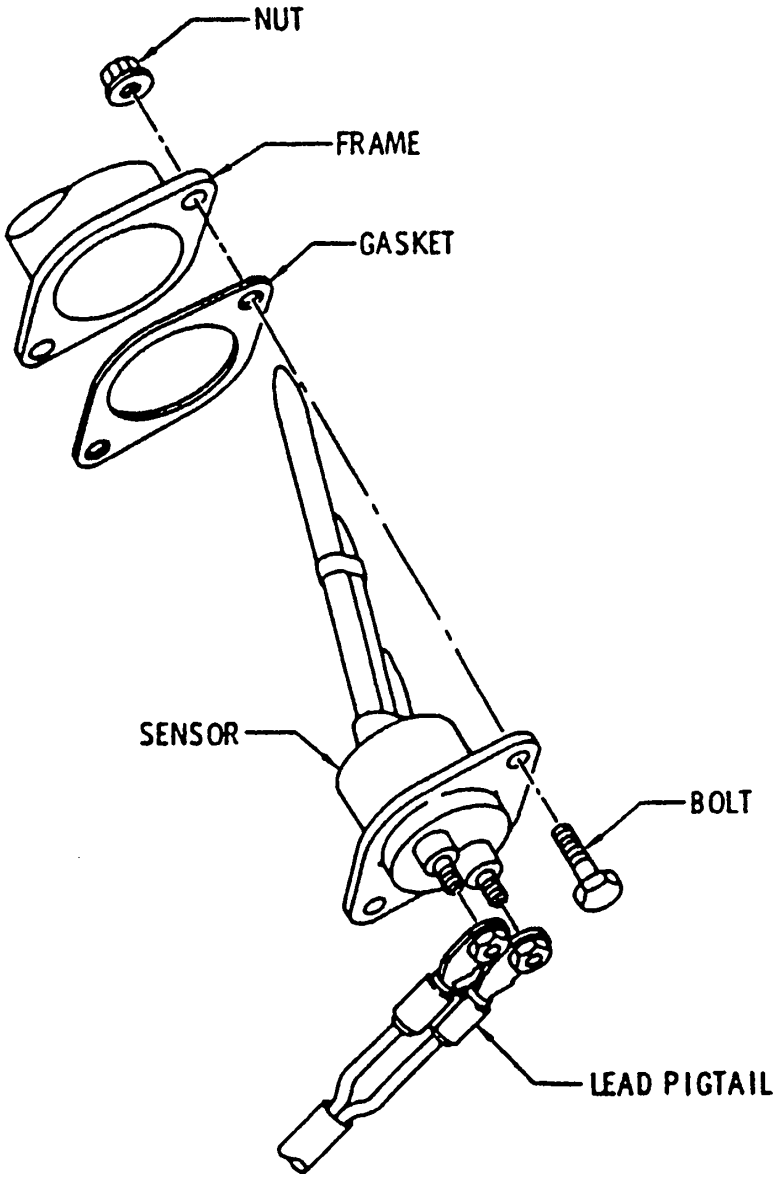
P4.9 Pressure Probe



Low Pressure Turbine Discharge Temperature

The T5 sensor is mounted at the 5:30 position on the Turbine Rear Frame. A separate cable harness is provided leading to an interface bracket on the left side of the compressor case at the 9:00 position.
The probe is designed as an integral unit consisting of two chromel-alumel thermocouples. The two immersion depths, one depth for ID airflow sensing and one depth for OD airflow sensing. The unit has stud type terminal connectors, one large chromel and one smaller alumel. The two thermocouples in the sensor are paralleled inside the probe to provide an average flow temperature signal of the exhaust gases. The EMF output of the type K thermocouples is plus/minus 2.2 deg.C.

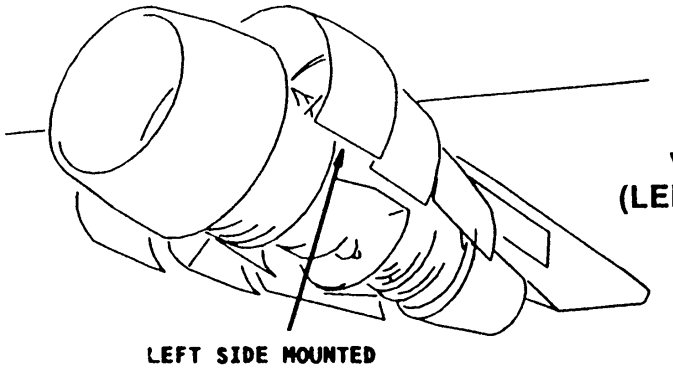
T5 Sensor



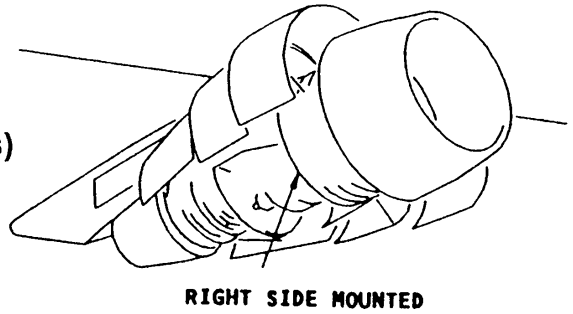
VSV Linear Displacement Transducer (LVDT)

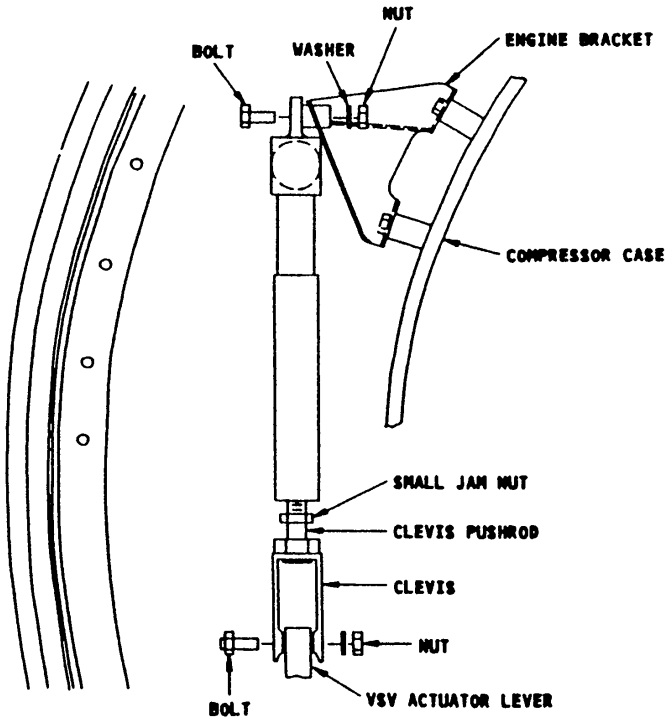
The variable stator vane position transducer is a variable ratio transformer. It is similar to a conventional linear differential transformer except for the addition of a reference winding which serves, by a self canceling principle, to minimize temperature induced gain changes. The linear variable displacement transducer (LVDT), as it is commonly referred, is attached to the master arm of the variable stator system and measures the travel/position of the entire system as it translates open/closed in relation to the compressor case. Displacement of the transducer moves the internal transformer core to establish various transformer phase relationships.

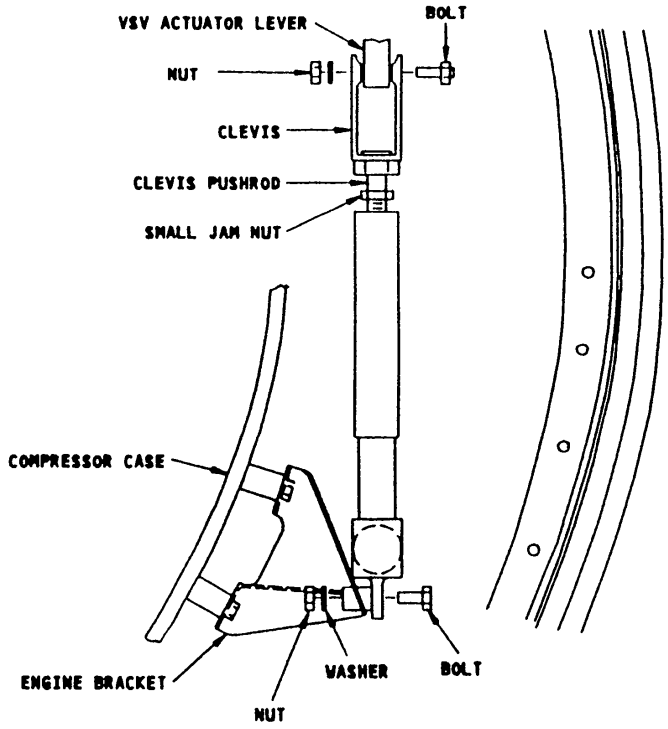
VSV LVDT



VSV LVDT INSTALLATION
(LEFT and RIGHT configurations)



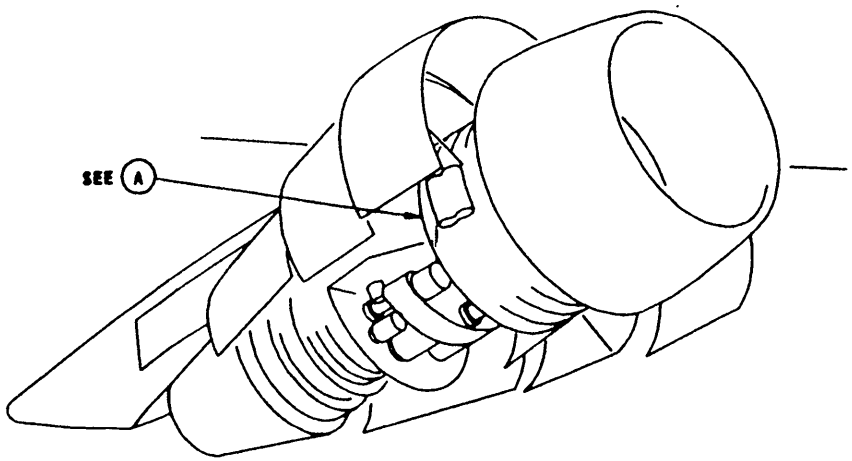


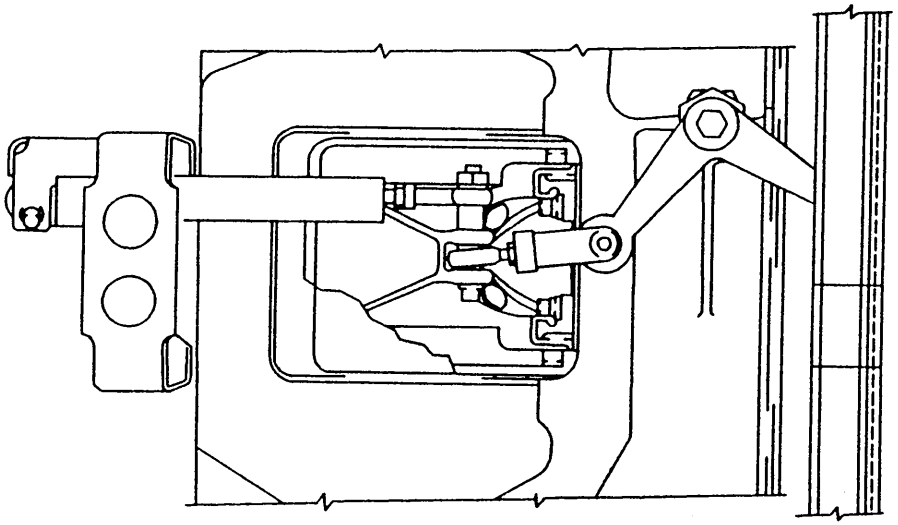


VBV Linear Variable Displacement Transducer (LVDT)

The variable bleed valve position transducer is a variable ratio transformer. It is similar to a conventional linear differential transformer except for the addition of a reference winding which serves, by a self canceling principle, to minimize temperature induced gain changes.The linear variable displacement transducer (LVDT), as it is commonly referred, is attached to one of the bleed doors of the variable bleed valve system and measures the travel/position of the entire system as it translates open/closed in relation to the fan frame. The transducer is mounted between the aft inner acoustic panel mount bracket, and the bleed door clevis bolt at the 3:00 position. Displacement of the transducer moves the internal transformer core to establish various transformer phase relationships.

VBV LVDT Installation





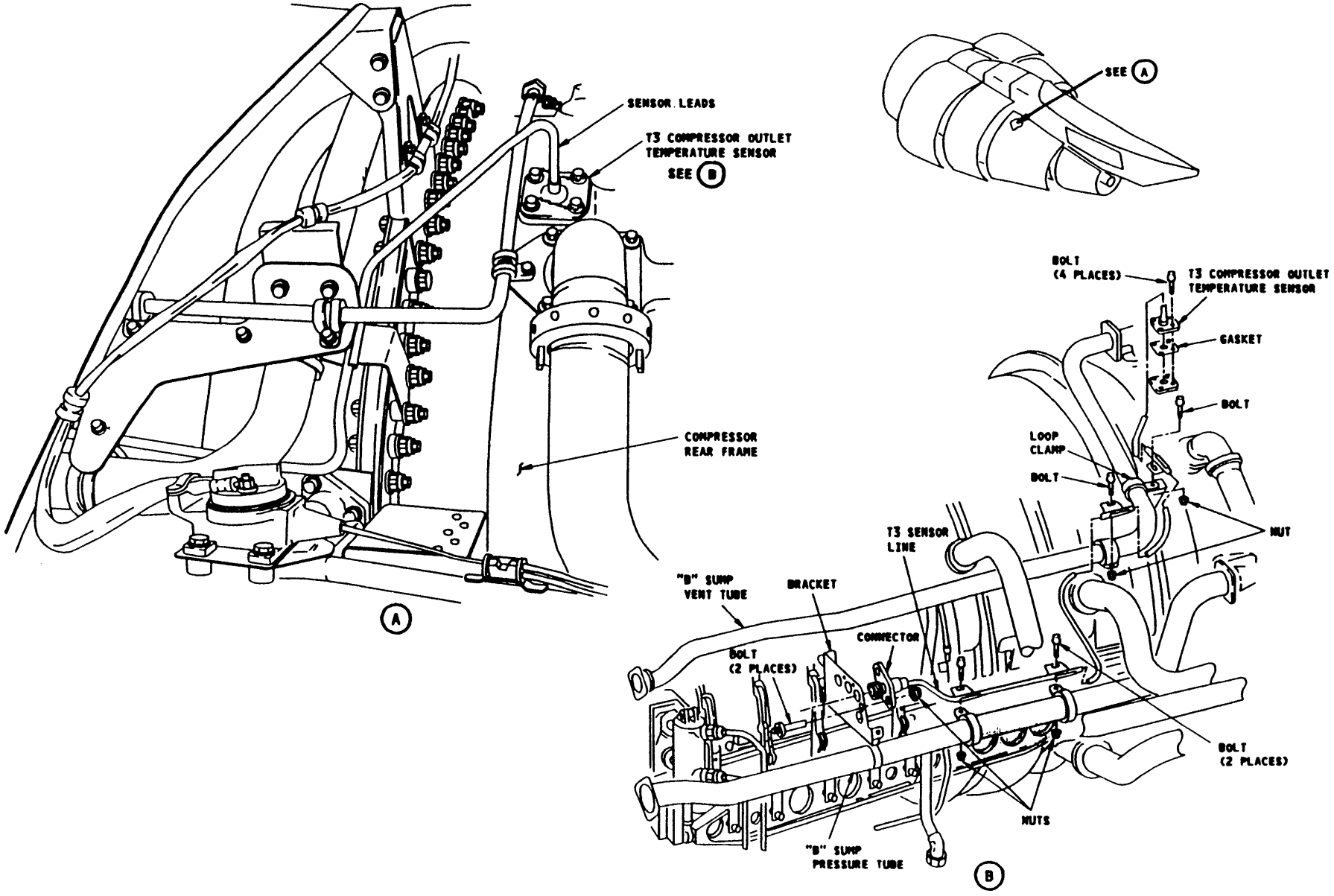
VBV TRANSDUCER
A

Compressor Discharge Temperature Sensor (T3)

The compressor discharge temperature sensor is dual chromel / alumel thermocouple located at the 11:30 position of the compressor rear frame.

The sensor has dual output leads encased within ceramic, enclosed by metal tube, or lead. The sensor assembly is preformed for the engine application to which it is installed. The lead is routed forward to a bracket on the compressor case at the 9:00 position. The dual connector facilitates individual outputs to the PMUX as well as a temperature signal to the aircraft Enviromental System in controlling the High Pressure Bleed Valve operation.

T3 Sensor


SENSOR LEADS
T3 COMPRESSOR OUTLET TEMPERATURE SENSOR
SEE B
COMPRESSOR REAR FRAME
A
SEE A
BOLT (4 PLACES)
T3 COMPRESSOR OUTLET TEMPERATURE SENSOR
GASKET
BOLT
LOOP CLAMP
BOLT
NUT
T3 SENSOR LINE
"B" SUMP VENT TUBE
BRACKET
CONNECTOR
BOLT (2 PLACES)
BOLT (2 PLACES)
NUTS
"B" SUMP PRESSURE TUBE
B

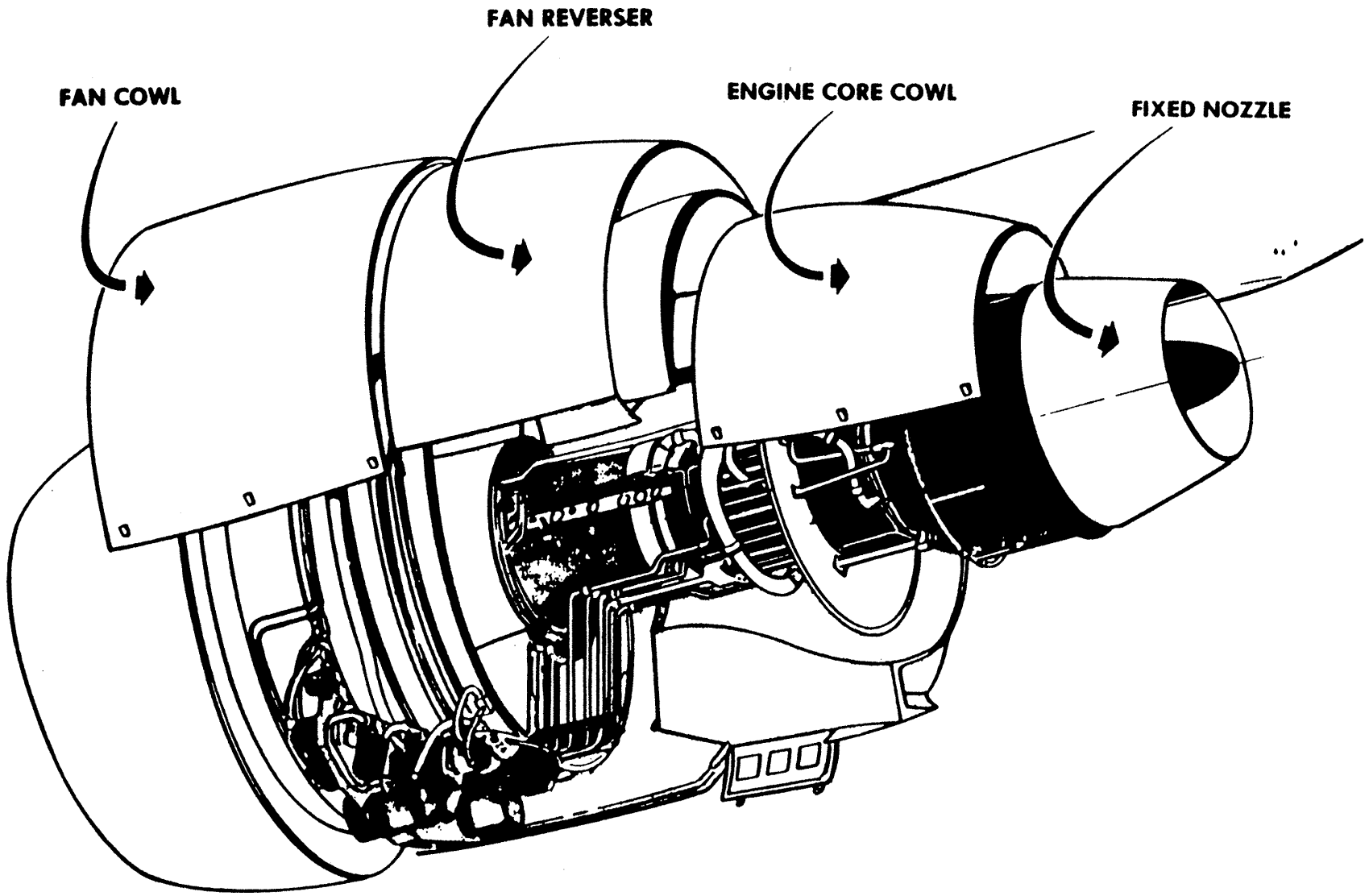
This engine uses a fan reverser to form engine cowling and to provide an exhaust nozzle and mechanism to reverse the fan exhaust. The core engine exhaust is through a structure providing a fixed nozzle. The thrust reverser functions on cockpit command. The operating configurations are forward thrust and reverse thrust. The thrust reverser is of a left and a right hand fan reverser assembly. The fan reverser, like the fan cowl and the core cowl are part of the pylon assembly and are not removed with the engine while the inlet and the core fixed nozzle are removed on engine change.

The fan reverser assembly is located directly aft of and is clamped to the fan aft stator case. It forms a bifurcated duct for fan exhaust when the separate left and right hand assemblies are latched into place. The separate left and right hand assemblies are independently supported from the pylon by three hinges each. The latching system consisting of an upper and lower forward latch, each half clamping to the aft fan case, three lower latches clamping the left and right half together and deflection limiters and wear pads providing the structural integrity needed to retain the cowling to the airplane and to retain its intended shape. To assist the maintenance function, hydraulic power opening actuator systems are provided for each half, and hold open support rods prop the open cowl safely.

The left and right half are mirror images. The several parts isolated for discussion purposes are riveted, bolted, bonded or welded together to form a single fabrication.

Duct sidewall, upper and lower, are aluminum honeycomb bulkheads to separate the inner and outer flow path surfaces formed by the inner cowl and the translating cowl. Combined with the twelve o'clock and six o'clock struts of the fan frame they provide a flow splitter and a cavity for engine service tubes, control rods, etc. The upper sidewall includes three hinge clevis forgings, power opening actuator support/reaction forging three deflection limiters and wear pads.

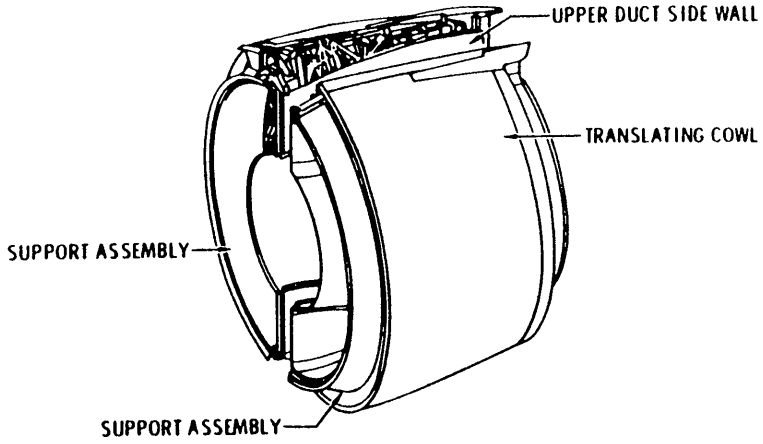
Thrust Reverser

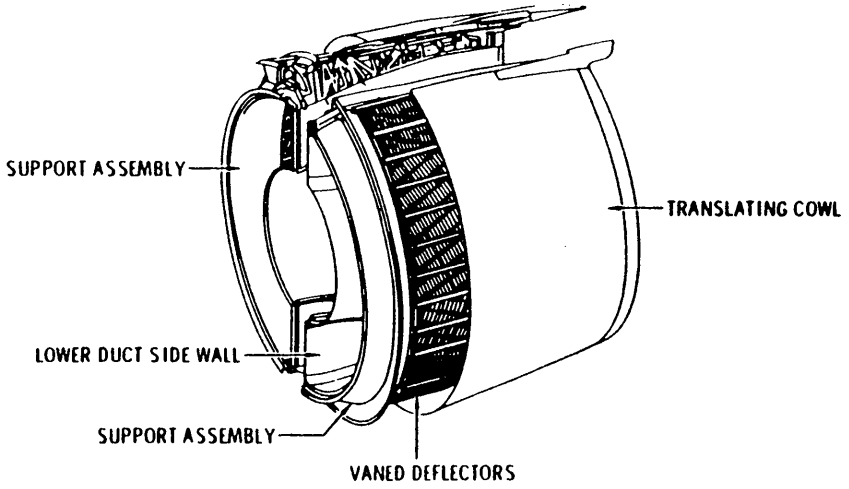


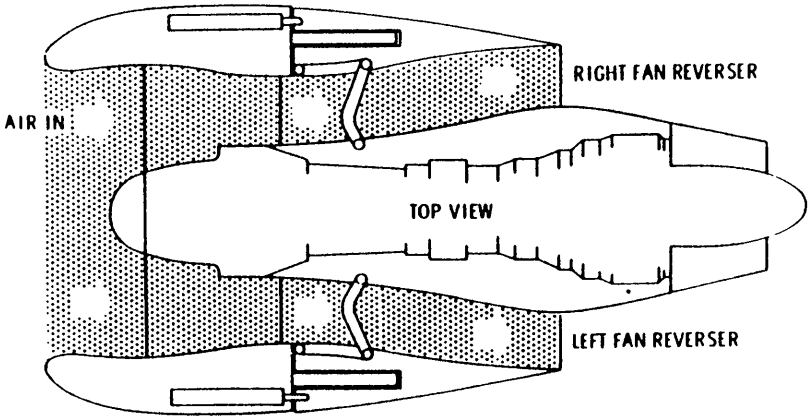
Thrust Reverser Assembly

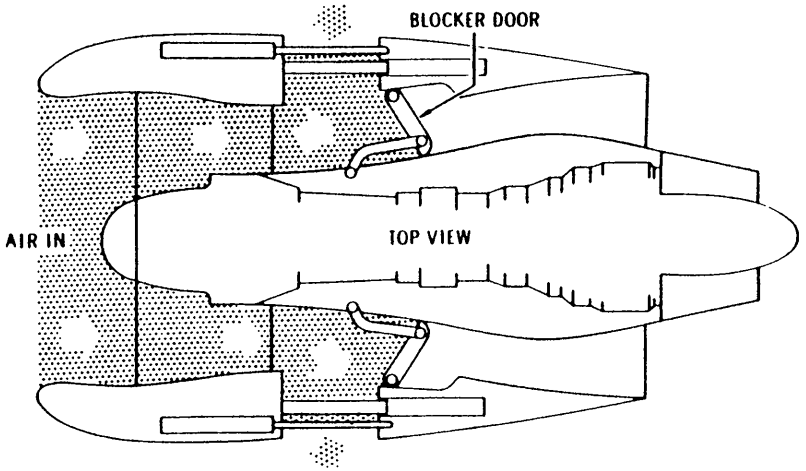
The redirection of fan discharge air through the deflector vanes rather than through the fan exhaust nozzle results in an efficiency loss in the airflow utilization. The reverse thrust resulting from the same fan speed is approximately 40% of the thrust that is available in forward mode. Since increased fan speed to increase reverse thrust requires a commensurate increase in core speed, and core thrust is not reversed", there is an optimum reverse fan/core speed. Flight test indicates the maximum net reverse thrust is obtained at approximately 95% N1 This is a reverse thrust of approximately 9000 lbs. The weight of the two reverser halves is 1322 lbs. combined. It is broken down as 1002 lbs for fixed structure, transcowl 293lbs, and pylon interface of 27 lbs.

Thrust Reverser Assembly









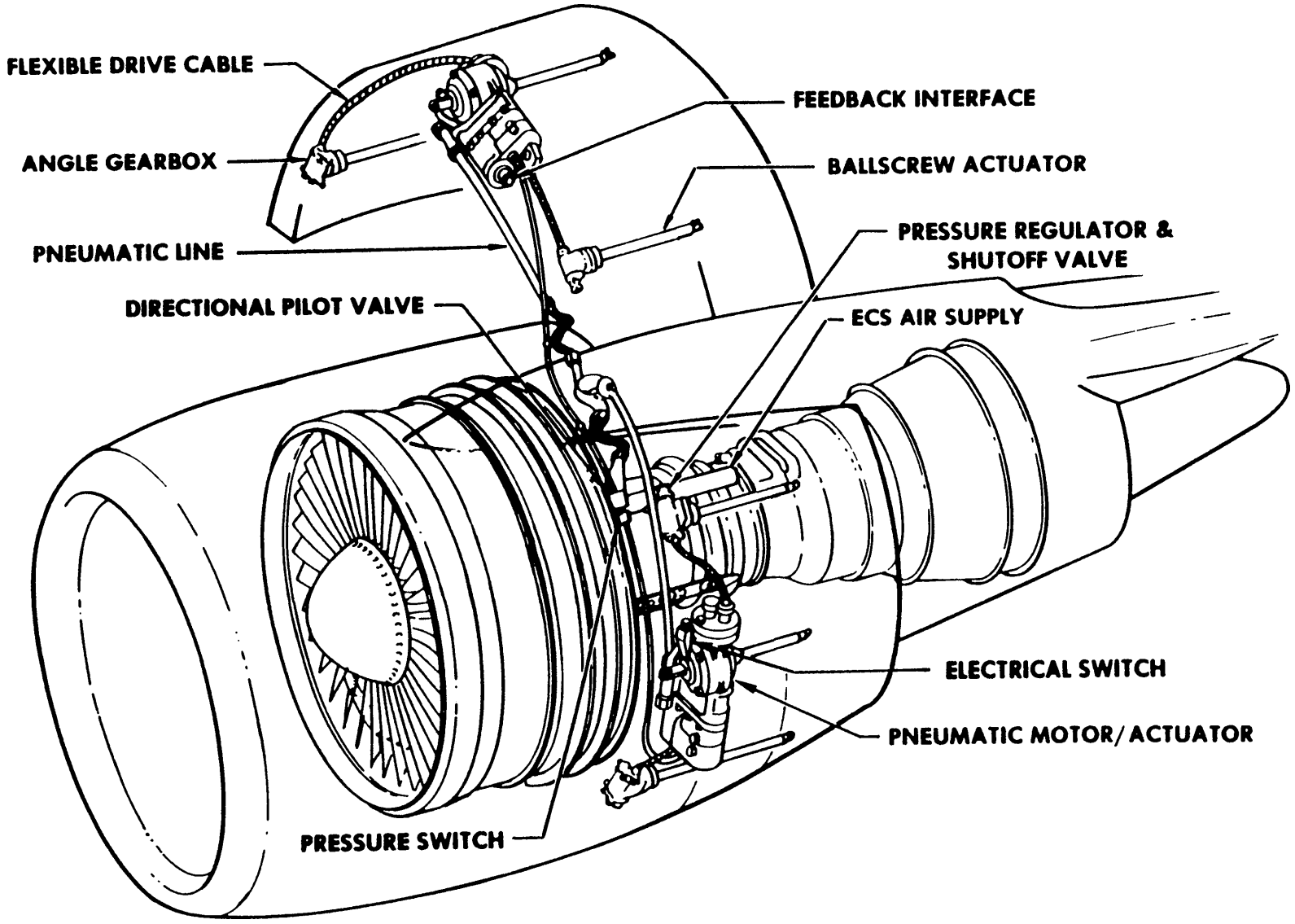
STOWED

DEPLOYED

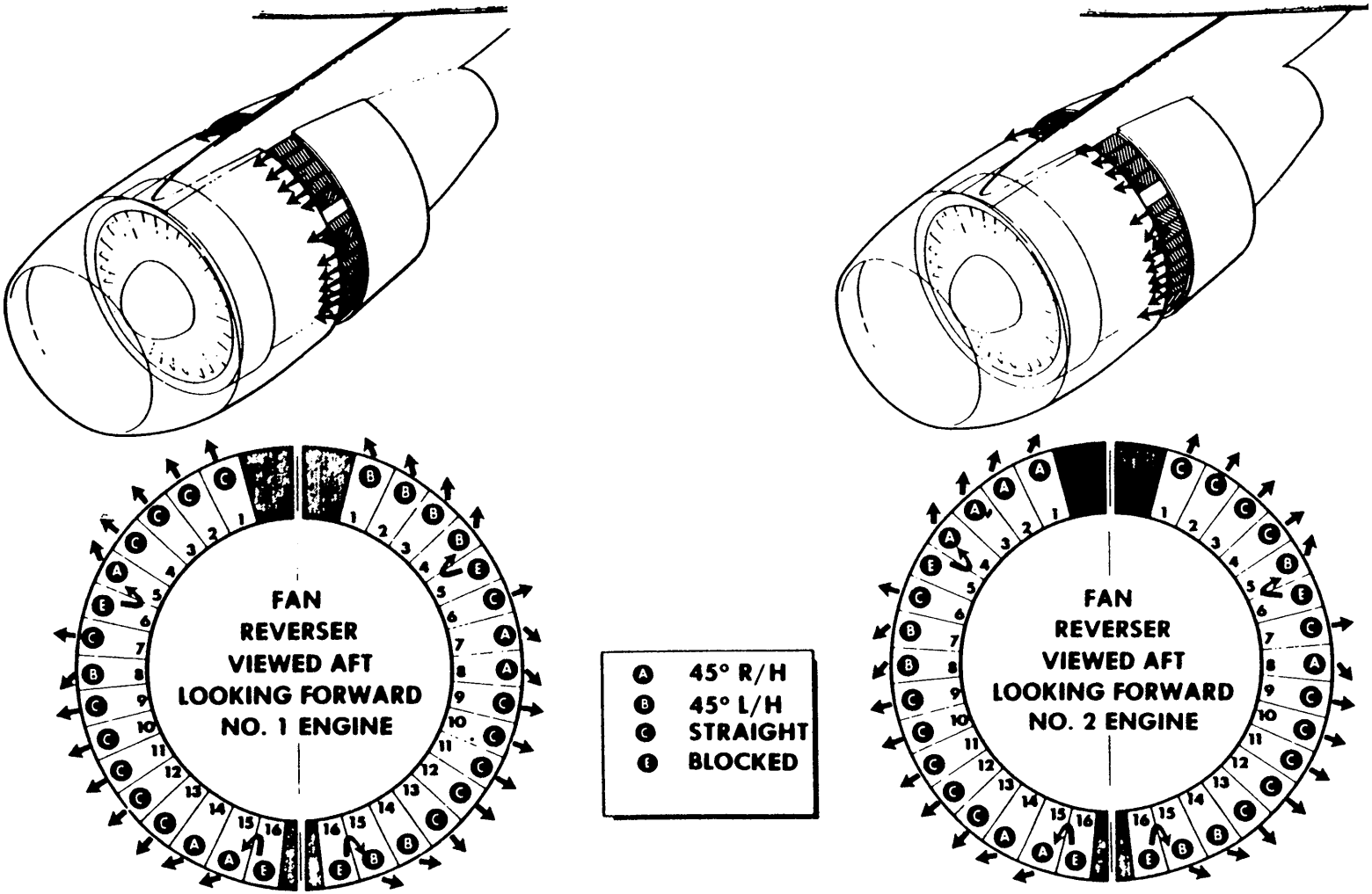
Thrust Reverser Assembly

Each fan reverser half assembly is operated by a single pneumatic motor, powered by the aircraft pneumatic system. The motor drives ballscrew actuators through flexible shafts and gearboxes to translate and rotate reverser components to the desired position. Sources of air supply are provided in airframe installations for maintenance functions. Appropriate interlocks and position-indicator switches are incorporated in the system. The system is not designed for operation in flight.

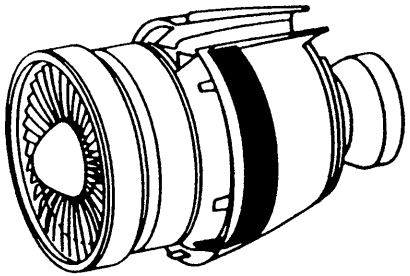
Thrust Reverser System

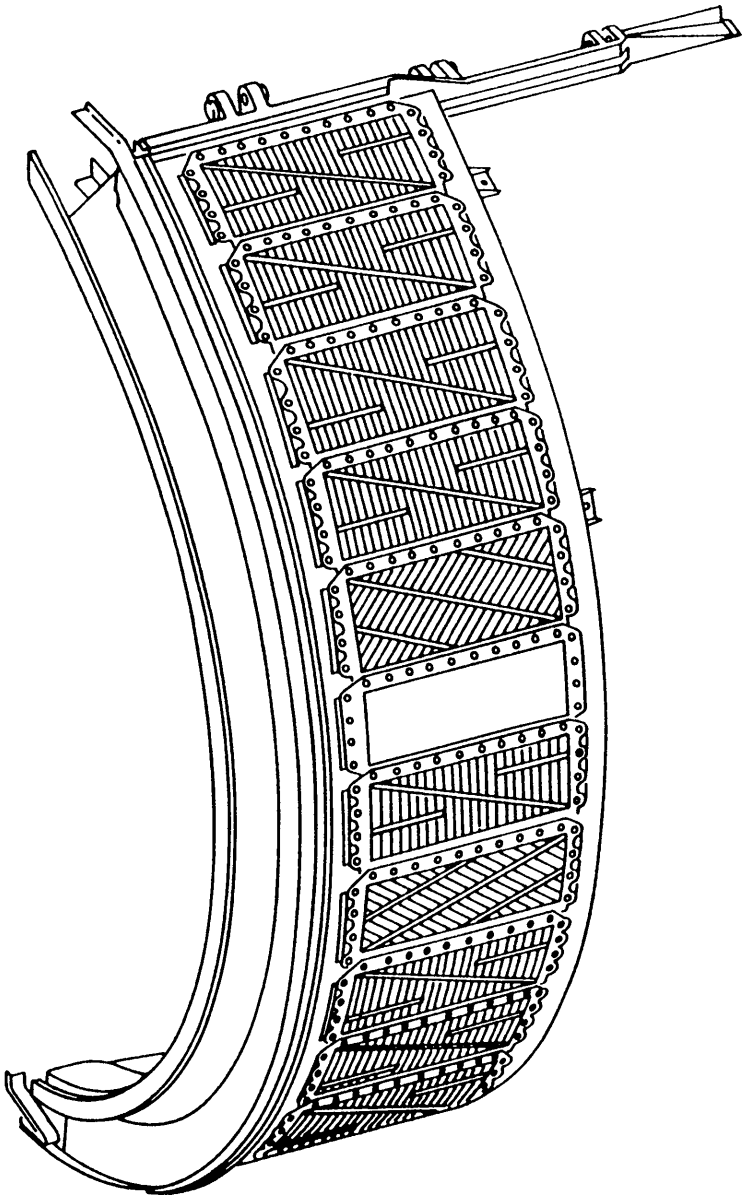


Deflector Vane Configuration



Deflector Vane Installation



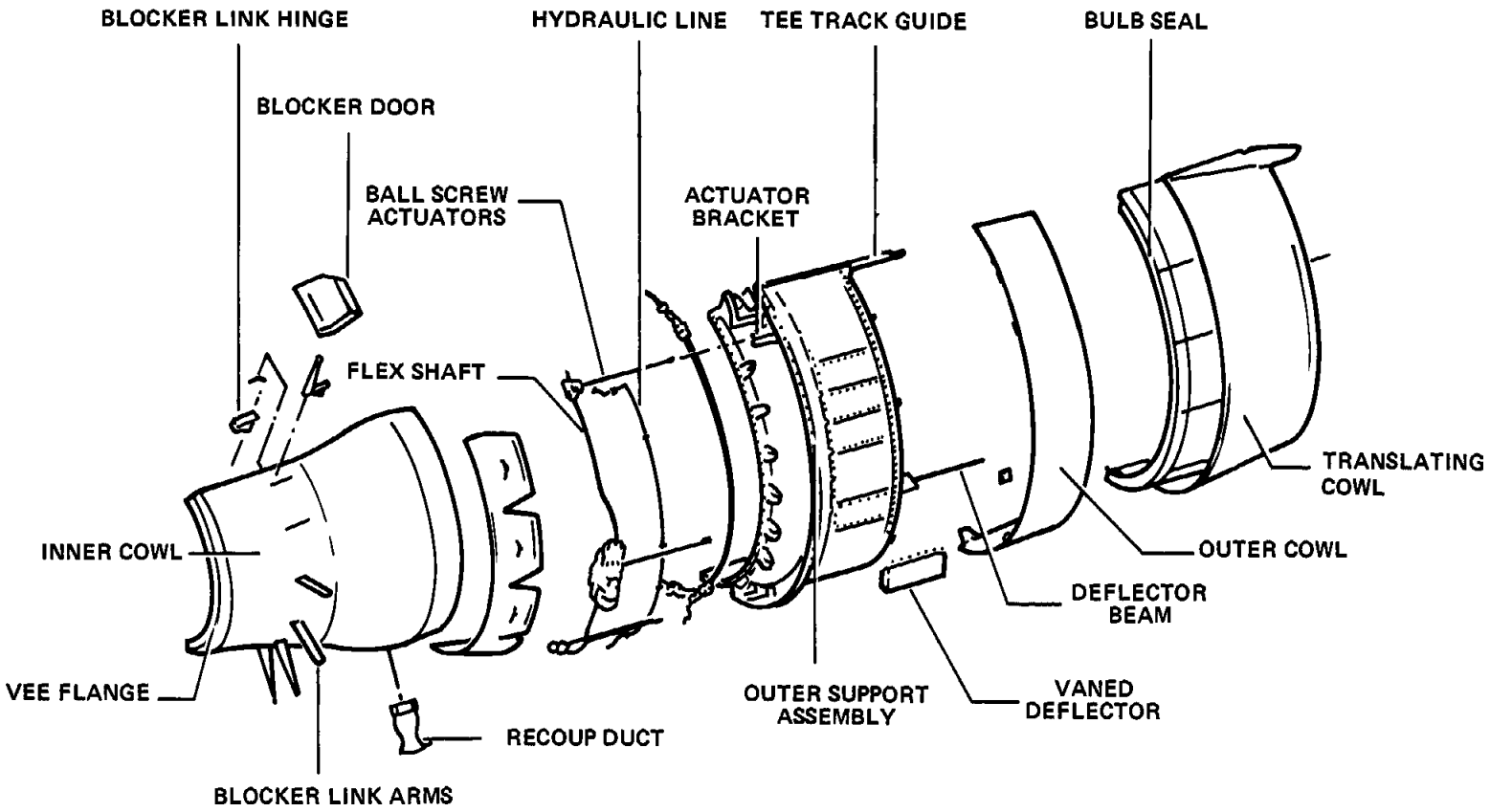


Inner cowl is an aluminum acoustic honeycomb bondment providing an aerodynamic inner flow surface for the fan duct and a core engine forward cowl. The cowl is riveted to the duct sidewalls. On the forward edge of the cowl a partial vee band flange engages a groove on the fan frame. A faying surface for engagement of the overlapped core engine cowl is on the aft inner surface. Six hinge boxes for blocker door link assemblies are attached to each inner cowl. Air extraction ducts and vents penetrate the inner cowl for fan air pre-cooler, compartment cooling, low pressure recoup venting. Zee rings riveted to the inner surface provide additional stiffening to honeycomb.

Outer support assembly is a riveted and bolted framework of aluminum sheet and extrusions support the translating cowl and the vaned deflector assembly. It is riveted to the duct sidewalls. It is supported and stiffened by a forward latch ring assembly which engages a Vee on the outer aft fan case and hooks twelve and six o'clock to the fan case. Tee slots and beam deflectors, which are teflon lined, provide guideways and support to the translating cowl. Forward fairing panels: Three pieces, acoustically treated, composite material, attached by screws. Provides outer flow path between the fan case and the translating cowl blocker doors.

Vaned deflectors are cast aluminum. The blank off panels are aluminum. The panels are bolted to the support assembly to provide various optional patterns of air reflection. The system panels, each half, are selected based upon engine position, inboard or outboard half, and for aerodynamic and braking effective panels are individually replaceable except at the five deflector beams where it is necessary to loosen the adjacent panel for access to hidden flat head bolts. Brackets are assembled onto the fixed structure to support two ballscrew actuators, and the center drive unit (CDU). The CDU is also supported on the forward end by two axial pins of a bracket accepting radial and vertical loads.

Fan Reverser, Exploded - Left Side



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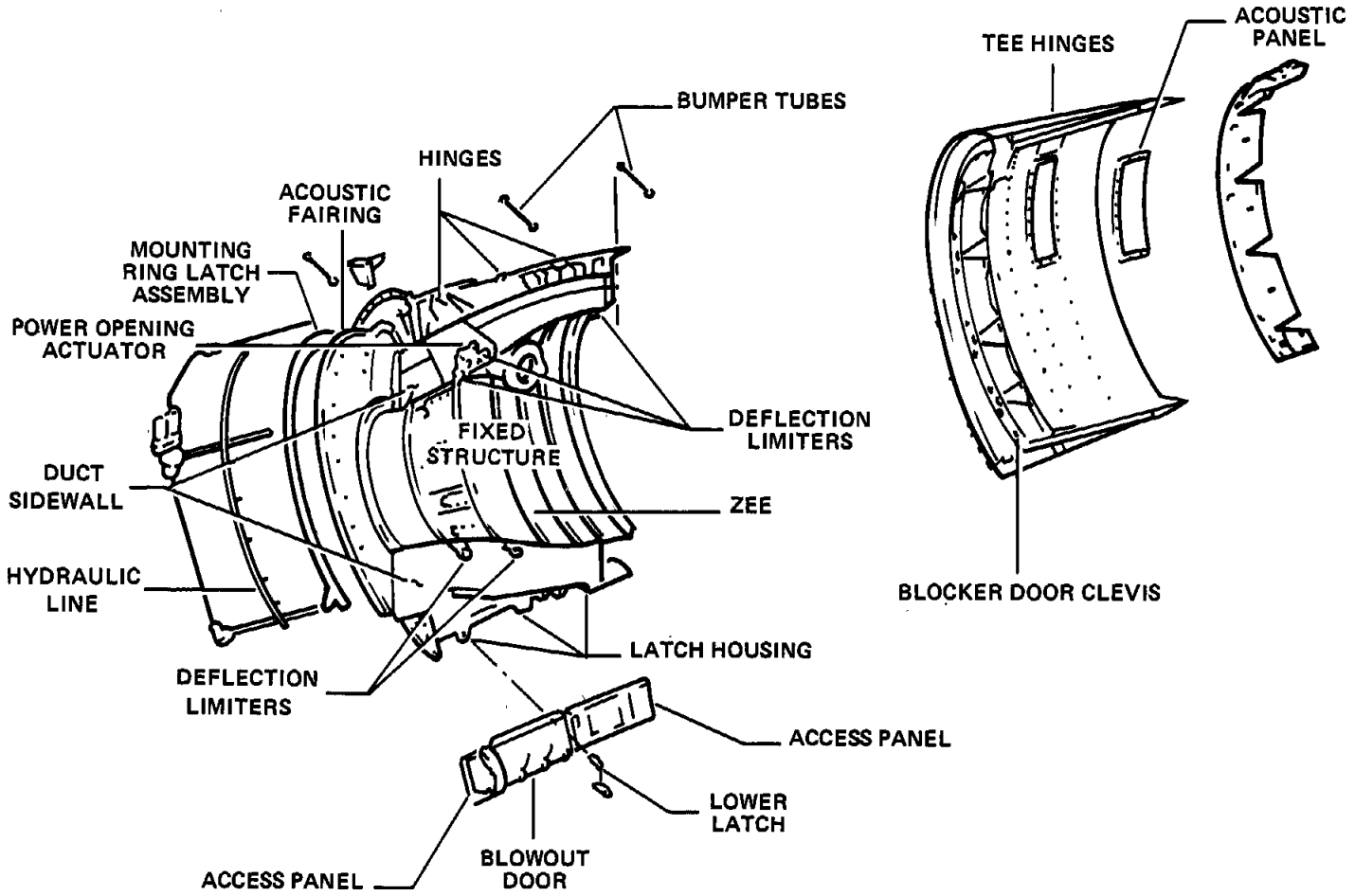
Fan Reverser, Exploded - Ride Side



Mounting Ring Latch Assembly

Secures the outer leading edge of the fan reverser halves to the aft flange of the fan case and transmits reverser loads into fan frame and not to hinges in pylon area. This is a half Vee band type quick disconnect flange mounting ring. It is teflon coated. The top latch of the mounting ring is a hook that slips into a "U" bolt bracket atop the fan stator case. The "U" bolt is adjustable to control upper latching force.

Lower Latches

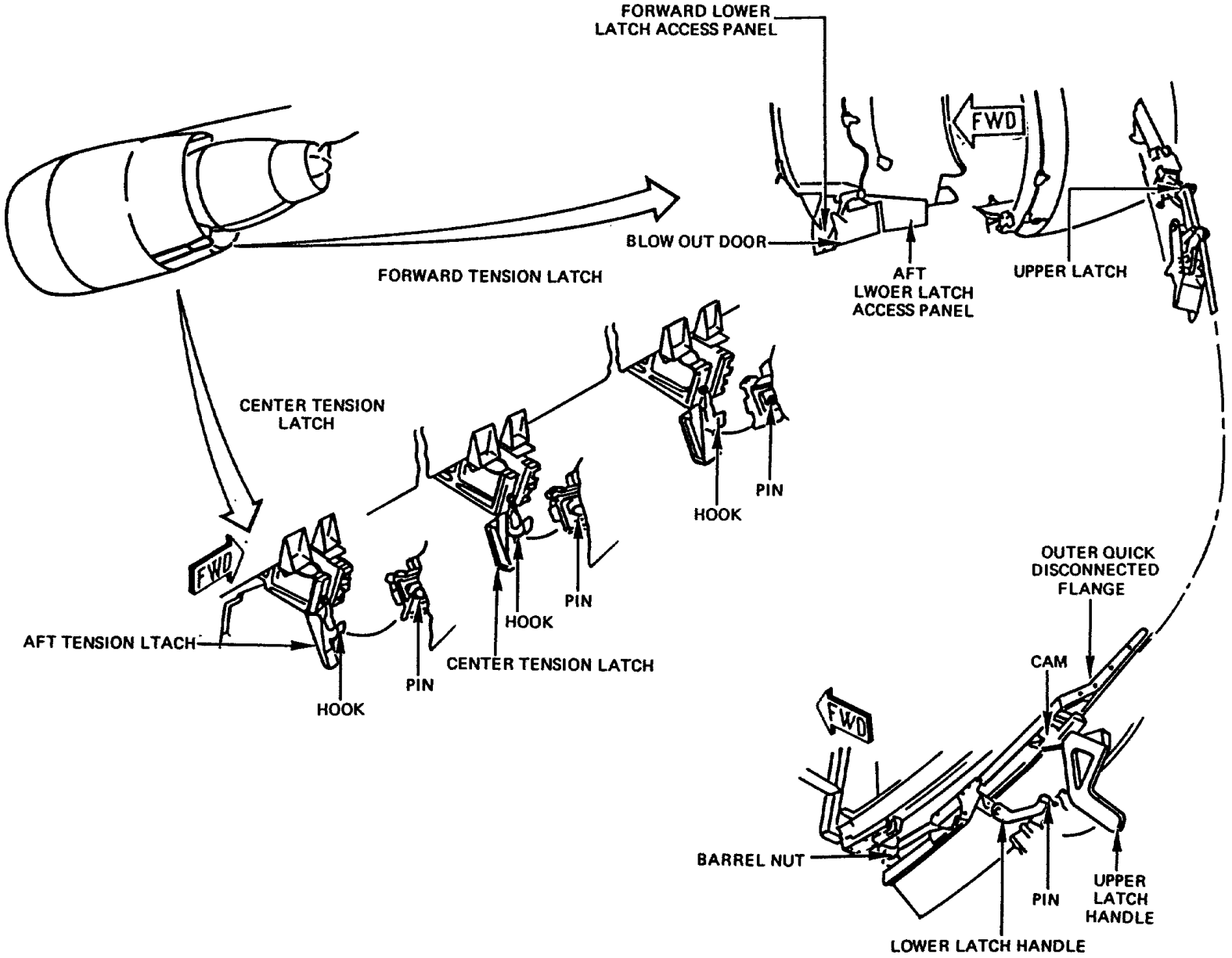
Interconnect the fan reverser halves at the bottom mid-section. The latches are located within the area covered by the access panel. Latch handle tension is adjusted by eccentric bushings position.

Access and Blow-out Door Assembly

A three piece design. The panel is hinged to the right hand half and fastened to the left hand half. Only the center section has blow-out function, it must open first and close last. The aft section has vent port. The bottom latch is a barrel nut that fits into a “claw” type clevis bracket a the bottom of the fan case. The barrel nut is adjustable to control latching force.

The exposed aluminum surfaces are protected with an intumescent coating for fire protection.

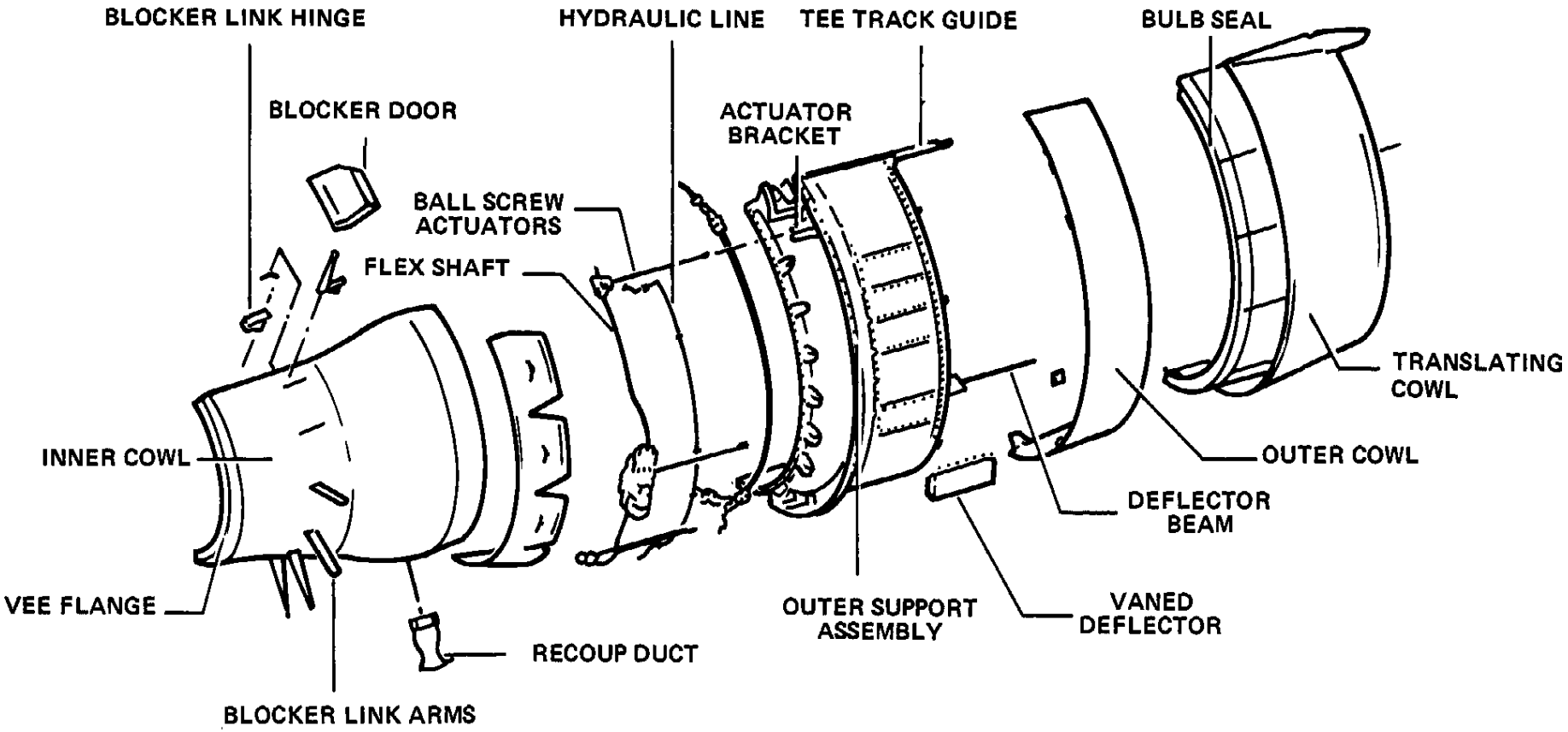
Fan Reverse Latches



Translating Cowl

A construction of composite material of Kevlar/Graphite/fiberglass facesheet with Nomex core. Hinges and pockets are bonded in. The structure provides an outer flow path for the fan air, a smooth low drag outer cowl, and a pocket to enclose the vaned deflector assembly in the stowed position. The transcowl is positioned by three ballscrew actuators whose rod end bearings are locked into cast pockets by removable pins. The translation is guided by teflon coated tee hinged rails engaging the Tee slots of the support assembly and five teflon coated strips sliding along the beam deflectors. Hinge clevises provide the forward pivot for the deployment of the blocker doors. In the stowed position a three piece bulb seal bolted to the transcowl at the forward edge of the blocker door support ring provides an aerodynamic seal of the deflector vane cavity. Attached to the outer cowl structure at the leading edge are ten nylon bumpers to engage and stiffen at the support structure plus two bumpers, one at top, one at bottom, including two captive nuts each for deactivation security of the transcowl. Six composite material honeycomb Bounds panels are attached by screws to the inner flowpath of each transcowl.

Fan Reverser, Exploded - Left Side

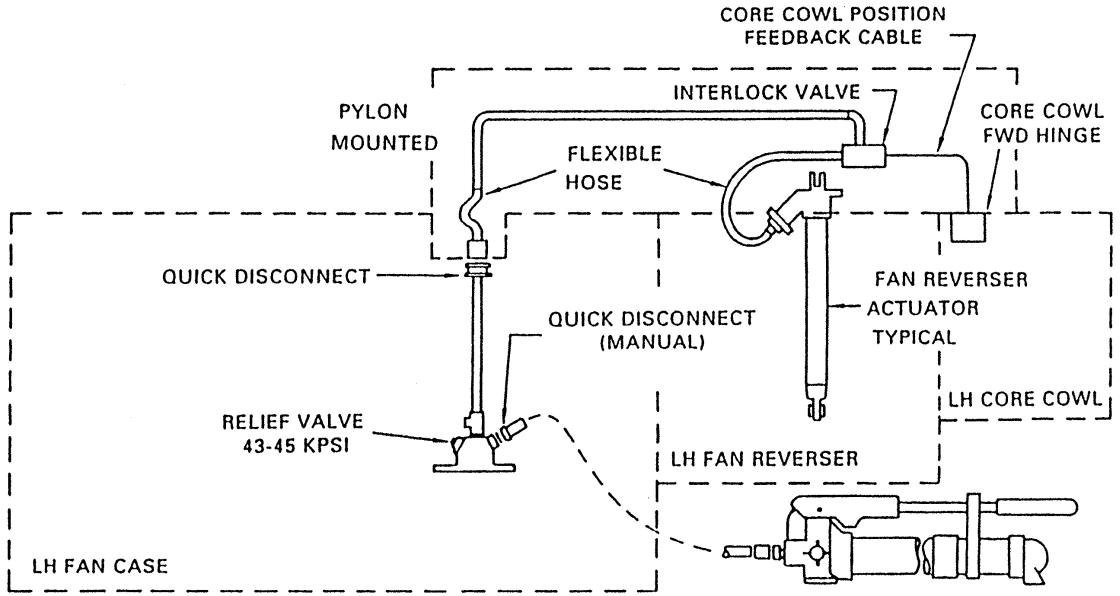


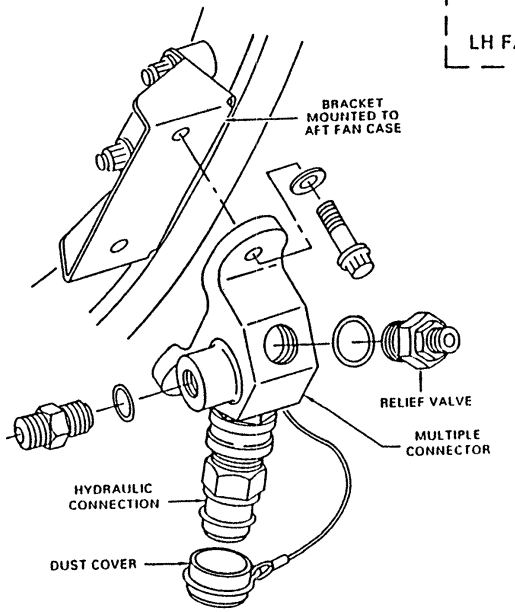
Cowl Door Hydraulic Actuator

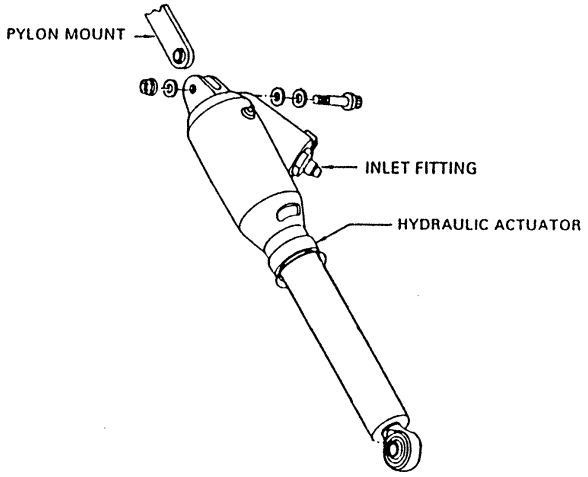
The actuator is driven by a portable hydraulic pump attached to a quick disconnect coupling at the lower ballscrew actuator of the transcowl deploy system. One actuator each reverser half permits it to be opened independently for access to the core engine. The actuators are mounted to the aircraft pylon and push against the actuator mount forging on the duct sidewall. Safety requires the use of a hold open rod before getting under an open cowl half. The aft faying surface of the reverser cowl overlaps the core engine cowling, therefore, the reverser must be opened before the core cowl can be opened.

The actuator inlet fitting incorporates a restrictor as a safety device limiting the rate of closure. In the event of a hydraulic line rupture, the restrictor will provide approximately 15 seconds for personnel escape. A 25 micron filter at the input fitting protects the restrictor and actuator assembly from hydraulic fluid contamination. A cooling jacket assures actuator air cooling from an external source. The quick disconnect coupling includes a dust cover incorporating a fluid overflow container and a high pressure relief valve for the system set at 4350-4400 psig.

Cowl Door Hydraulic Actuator



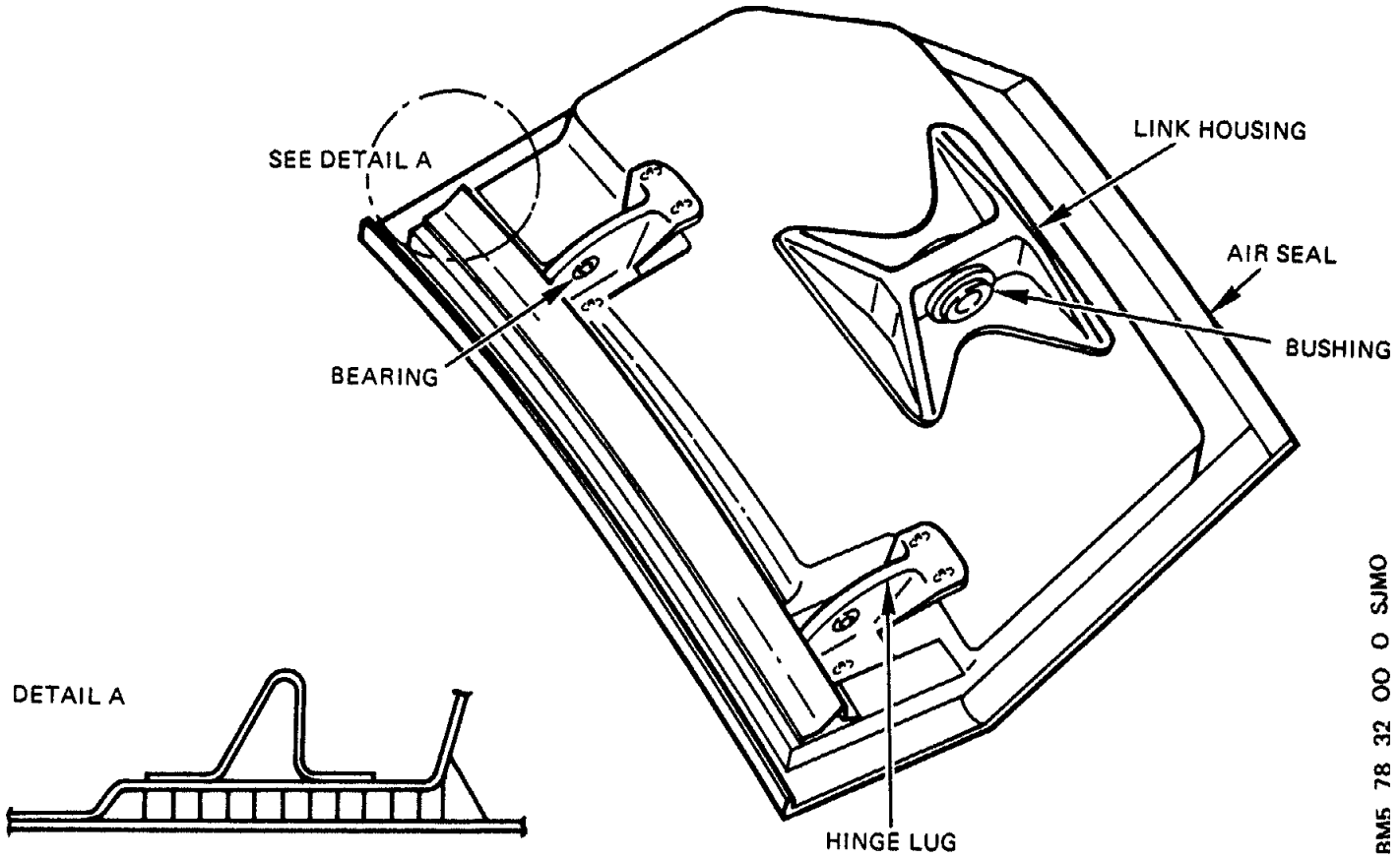




Blocker Door

Blocker doors are pivoted into the fan exhaust to block the normal flow path, requiring the fan air to exit through the vaned deflector assembly. A composite structure of fiberglass face sheet, graphite/fiberglass back pan with aluminum hinge castings bonded into place. The blocker doors are hinged on their forward edge to the translating cowl and bolted to the blocker link arm at the link housing near the aft edge. The blocker link acts as a radius rod controlling the rotation of the blocker door into the fan air as the trans cowl is deployed. The blocker doors are radially loaded by a 100 pound spring contained in the blocker link hinge box to avoid flutter when stowed. There are various patterns of blocker doors -standard, upper left and right, lower left and right. Six blocker doors are required each half.

Blocker Door



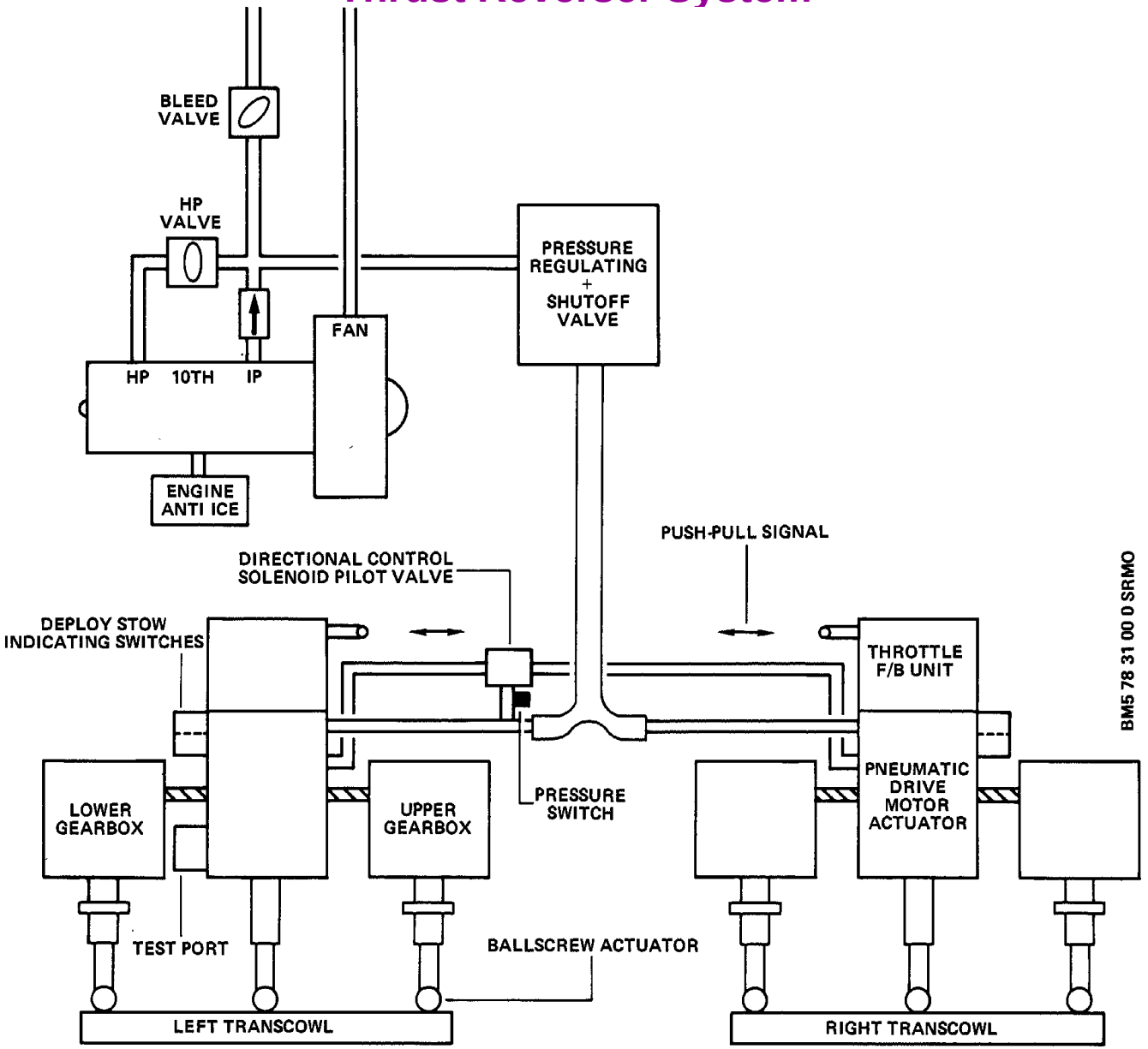
Pneumatic Supply Manifold

A duct supplies air to the two pneumatic actuator drive motors. In the duct is installed the pressure regulator and shutoff valve, a way to split the supply, two flexible hoses at the pylon hinge in the separate motor air supply tubes, and Directional Pilot Valve (DPV) on the left hand reverser half. The DPV in turn ports control signals to each CDU.

Reverser Control/Actuation System

The fan reverser transcowl is driven to deploy or stow position by three ballscrew actuators on each half of the fan reverser. The power to drive the actuators is aircraft bleed air ducted to each of two pneumatic actuator drive motors located at the center position of the transcowl actuators. The Center Drive Units (CDU's) are interconnected to the end actuator gearboxes through flexible cables. The pneumatic supply and the direction of drive motor rotation is controlled by dual cockpit commands to the pressure regulator and shutoff valve (PRV) and the directional pilot valve and pressure switch (DPV). Cockpit indication of transcowl position is provided by electrical limit switches. The system also provides for core cooling air exit temperature indication, system arming indication via the pressure switch, Variable Stator Vane (VSV) reset signal for reverse thrust and deenergization of the Pressure Regulator Valve (PRV) solenoid after stroke completion. Throttle feedback actuators, part of the CFU[3], position a push-pull cable proportional to the transcowl position. In a normal stow or deploy, the feedback of both reverser halves removes a throttle block permitting full engine rpm following 97% translation. In the event of inadvertent deploy, the push-pull cable will override the pilot command and drive the power lever to engine idle speed position.

Thrust Reverser System



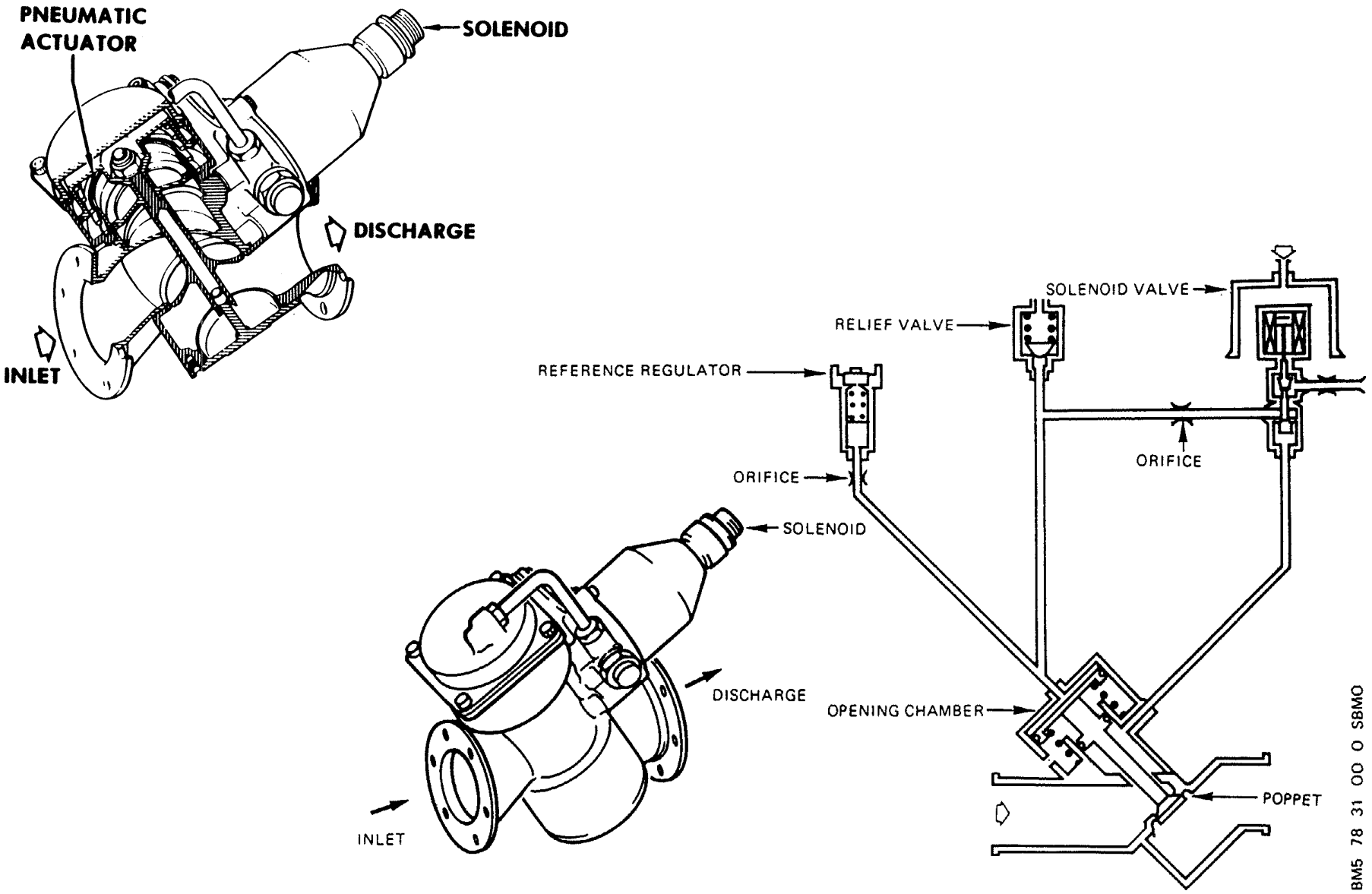
Pressure Regulator and Shutoff Valve

A normally closed valve with a 28V DC solenoid operated pilot. It is provided an opening electrical signal from the cockpit pedestal switch when the reverse lever is positioned to the reverse thrust interlock stop. It is installed on a standoff bracket on the upper compressor case at approximately stage 3. The valve is made of steel.

In operation mode, ECS air supply flowing across the solenoid valve pressurizes the opening actuator compressing the closing spring and overcoming the force on the smaller closing actuator. Regulation of downstream pressure is accomplished through the reference regulator venting opening actuator pressure above the reference set point of 70 psig. Inlet pressure changes are reflected in opening actuator pressures and downstream pressures are the result of the modulating poppet valve. Maximum downstream pressure will be limited by a relief valve which also vents opening actuator pressures at a predetermined value of 150 psig. Control orifices are placed in the servo line to reduce and dampen flow variations and to assist the relief valve regulation.

In normal deployment situations the ECS air supply pressure is not high enough to cause valve regulation to occur .In rejected takeoff condition however, the engine speed may develop enough 8th stage bleed pressure to drive the valve into the regulation mode i.e. above the reference regulator venting point of 70 psig. In this case the poppet will modulate to limit the downstream pressure. The solenoid is automatically deenergized when the commanded position is attained. If an unstowed condition should develop while the command signal is still in stow, the solenoid would be energized. This will open the poppet valve supplying regulated air to the center drive units to return the reverser to the stow position.

Pressure Regulator and Shutoff Valve

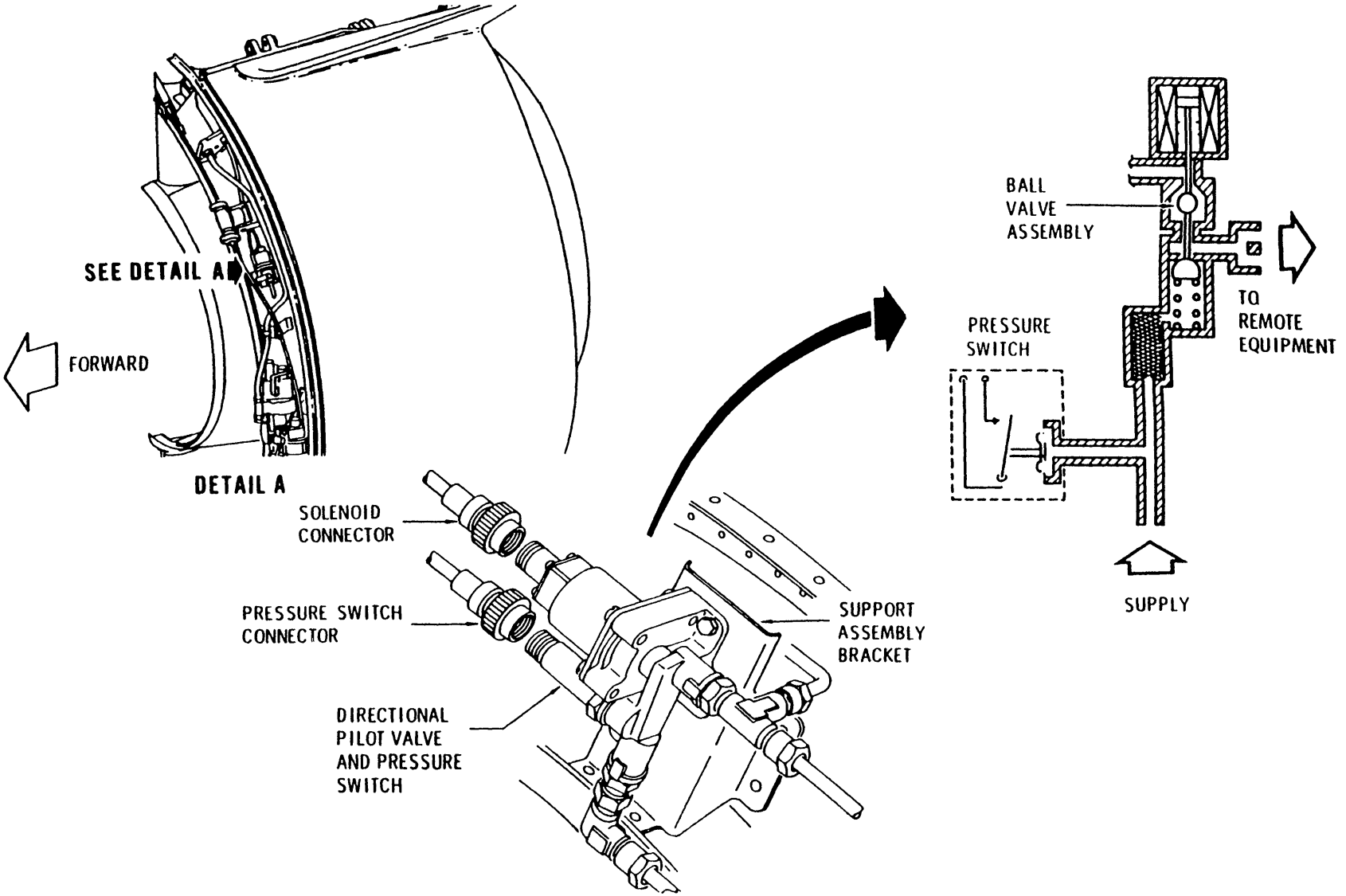


Directional Pilot Valve and Pressure Switch

This is a component providing two functions in one housing. The pressure switch can illuminate a cockpit light when the duct is pressurized confirming the arming of the thrust reverser system or the inadvertent pressurization due to a malfunction of the Pressure Regulator valve. This signal could also be placed in parallel with the stow switches. The directional pilot valve, when the solenoid is energized, will pressurize the directional control valve actuator in the CDU's with air to cause deploy rotational direction to occur in the drive motors. The component is installed on the left hand reverser half adjacent to the upper angle gearbox and ballscrew. It is teed into the left hand actuator air supply.

OPERATION: At the deploy command from the cockpit the solenoid will be energized.This will allow air to pressurize two tubes (flexible lines across the pylon area) of approximately equal length, one to each directional control valve of the center drive units. When the throttle is returned to the forward thrust mode, the solenoid will be deenergized, removing the ECS air from the directional control valve actuator. The CDU directional control valve will reverse the ECS air supply flow direction through the gear motor at this command.

Directional Pilot Valve and Pressure Switch



Functions and Purposes.

Left hand and right hand units are required. They are installed at the 3 and 9 o'clock positions on the fan reverser. It is multi-function component.

Functions and purposes

An air motor and directional control valve.

A gearbox and two drive pads to drive flexible cables to the reverser end actuators. There are two spare, redundant, drive pads which may be used for manual deployment. By inverting the cover plate, which has a square shank welded to it, the actuation system can be deactivated.

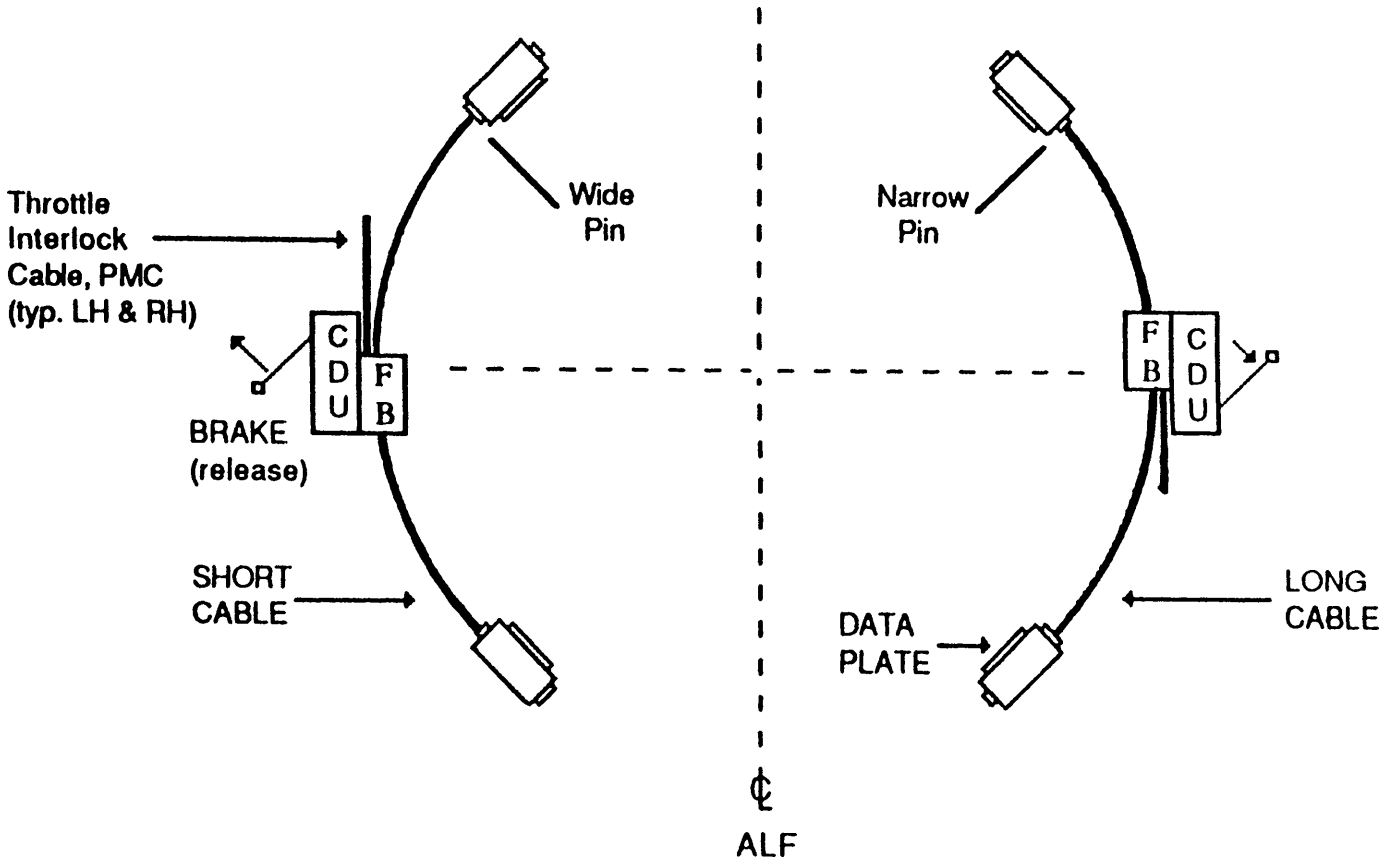
An internal stop rod which provides control feedback and a load path to absorb the shock of stopping the translating cowl at deploy and stow.

An indicating system of electrical switches to identify an unstowed and deployed condition.

A brake system to maintain the translating cowl in the stowed condition until commanded to deploy. A manual brake release is provided for maintenance purposes.

A rig position indicator and a sight peephole to verify rig position enable easy location of the reverser actuation system rig base line.

Drive Units


Throttle
Interlock
Cable, PMC
(typ. LH & RH)
Wide
Pin
Narrow
Pin
C
D
U
F
B
BRAKE
(release)
SHORT
CABLE
LONG
CABLE
DATA
PLATE
℄
ALF

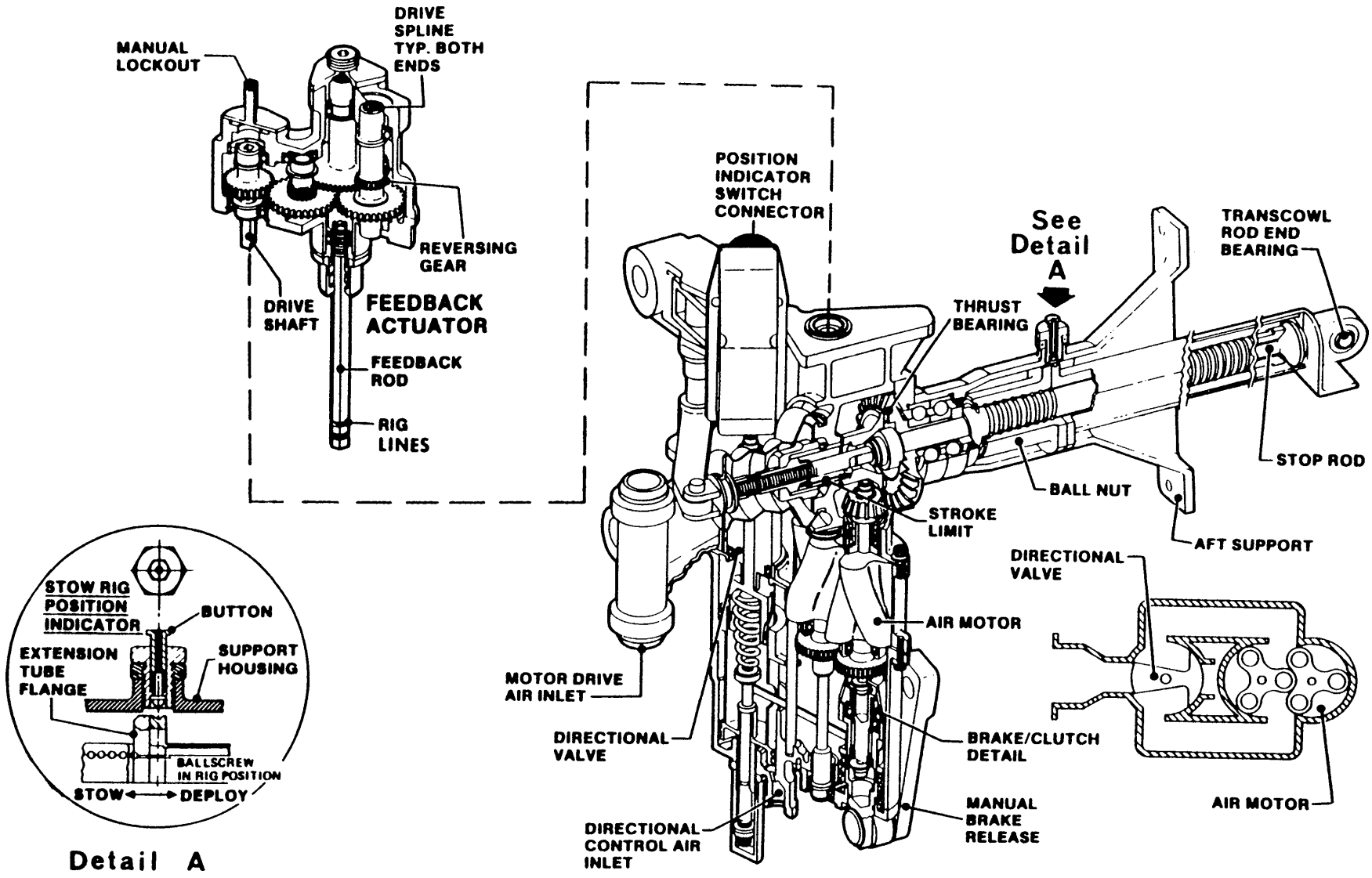
The CDU's require an air supply connected to either end of an inlet tee fitting. The other end is normally capped unless a ground air supply is to be provided for activation without engine operation. It is a 1” fitting. The ground air supply is available from a tap on the starter air supply duct. Air pressure from the directional pilot valve is applied to the CDU directional control valve actuator inlet port. Pressurization of the actuator will compress the return spring, rotate the helix shaft. to turn the directional control valve to the deploy position thus reversing the airflow direction through the air motor, and release the cone shaped brake to permit air motor rotation.

The air motor section consists of two-three lobed aluminum rotors synchronized by steel spur gears. One shaft drives the pinion bevel gear of the CDU ballscrew and is attached to the brake assembly. The other rotor shaft drives the feedback actuator assembly and the two auxiliary drive ports. (For a turbine reverser and a lockout port covered by a plate and lockout pin).
The hollow ballscrew shaft is rotated by the bevel ring gear translating the ball nut, the torque tube covering the ballscrew, and the translating cowl mid clevis pinned to the actuator. The upper and lower ballscrew actuators are driven synchronously with the center actuator through flexible cables installed to the feedback actuator assembly splined drive shafts.

Near the end of the deploy stroke, the aft shoulder of the ball nut contacts the mushroom head of the internal stop rod and begins the aftward translation of the stop rod, The stop rod is linked back to the directional control valve (DCV) which overrides the high speed deploy pressure command. As the actuator approaches its stop the DCV is closed thereby generating large air motor back pressures and rapid deceleration. The same operation of reducing the air supply inlet at full stow occurs, except there is a slot or bleed through the air exhaust port which maintains a pneumatic load on the drive cables as long as pressure is available, The brake will hold the cable pre-load and prevent rebound of the transcowl after striking the stops. Movement of the stop rod is limited by internal stops in a housing forward of the bevel ring gear .When the internal stops are contacted the translating cowl movement will stop. The stop rod is a spring which will absorb the remaining stopping loads. The load path is through a face type roller thrust bearing on the bevel ring gear into the motor/actuator mounting flange against the reverser fixed structure.

During the short translation of the stop rod, a clevis connection to a cam shaft link arm operates the position indicating switches. In stow the stop rod is compressed positioning the cam to deactivate the switches. As translation begins, initial movement

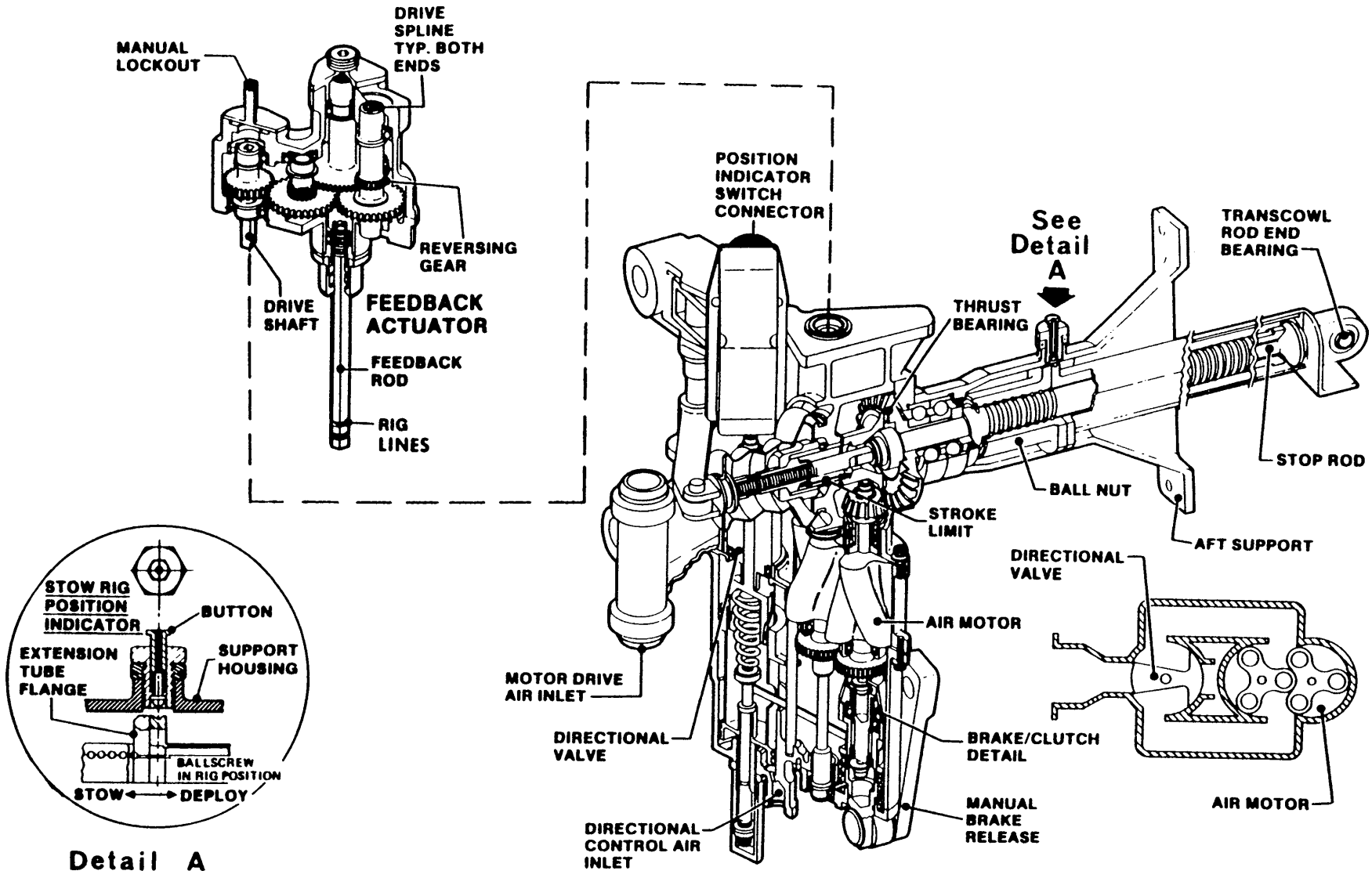
Center Drive Unit (CDU)



"makes" the unstow indicator light circuit. Near the end of stroke, contact of the stop rod mushroom end moves the stop rod and makes the green "reverse thrust" light and opens the unstow light circuit. The unstow indicator switch will also energize the Pressure Regulator and Shutoff Valve solenoid when that circuit is "made" by a failure resulting in a deploy movement of the translating cowl or actuator. The switches are line replaceable without rigging. All switches are in the one housing which is replaced as a unit.

Upon deployment, a linear actuator will retract into the feedback assembly housing pulling on a flexible cable of the throttle interlock system. At the required number of turns of the CDU, the feedback actuator will have removed the aircraft throttle block. The turns of the CDU are directly proportional to the transcowl position. The actuator rod contains two rig reference lines representing the min.-max, tolerance for rigging. The housing containing the feedback actuator rod permits the rod to be reversed. This reversal converts the CDU from a right hand to a left hand unit. It must be reworked at the shop level. The gear shafts which develop the reversal of the feedback direction also provides the output 12 point spline drive sockets for the end actuator flexible cables.

Center Drive Unit (CDU)



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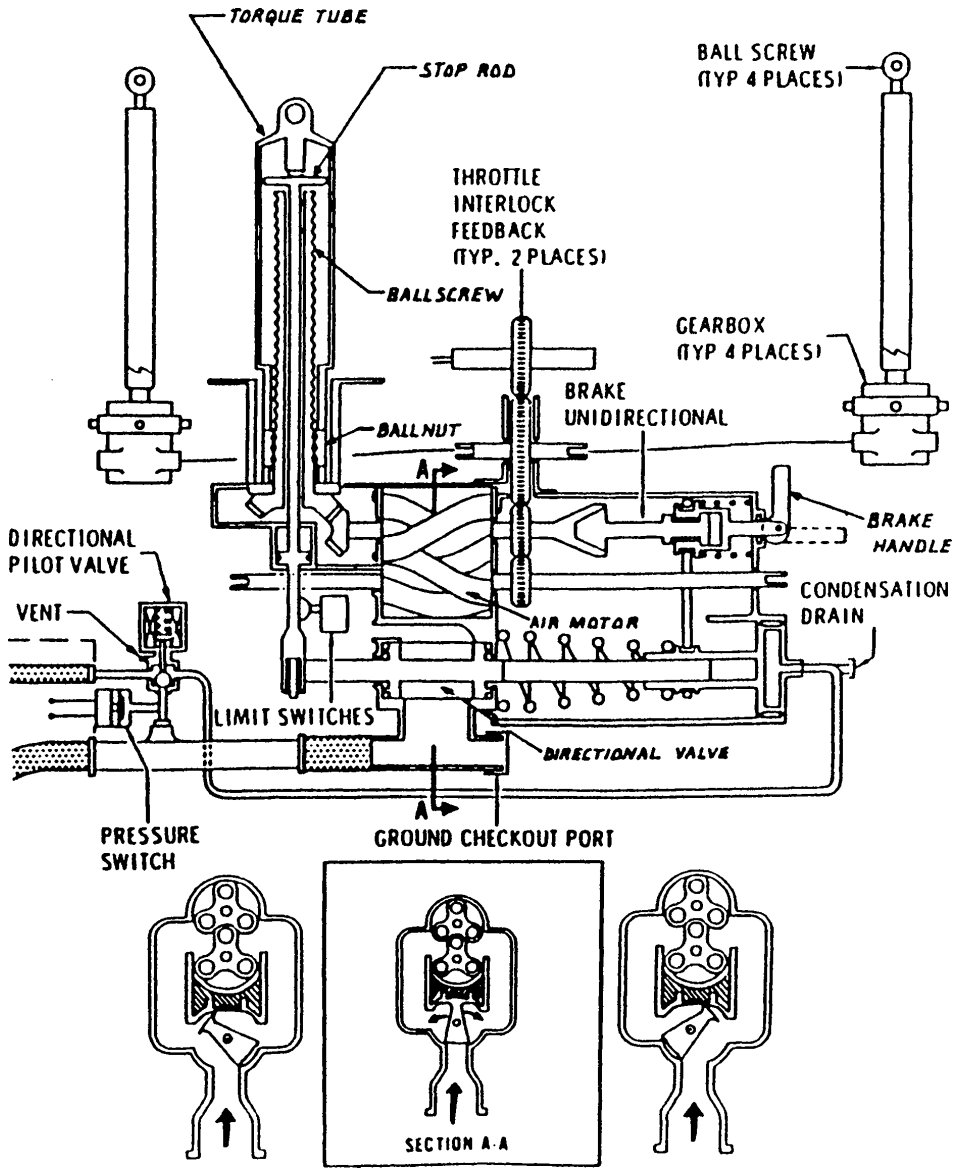
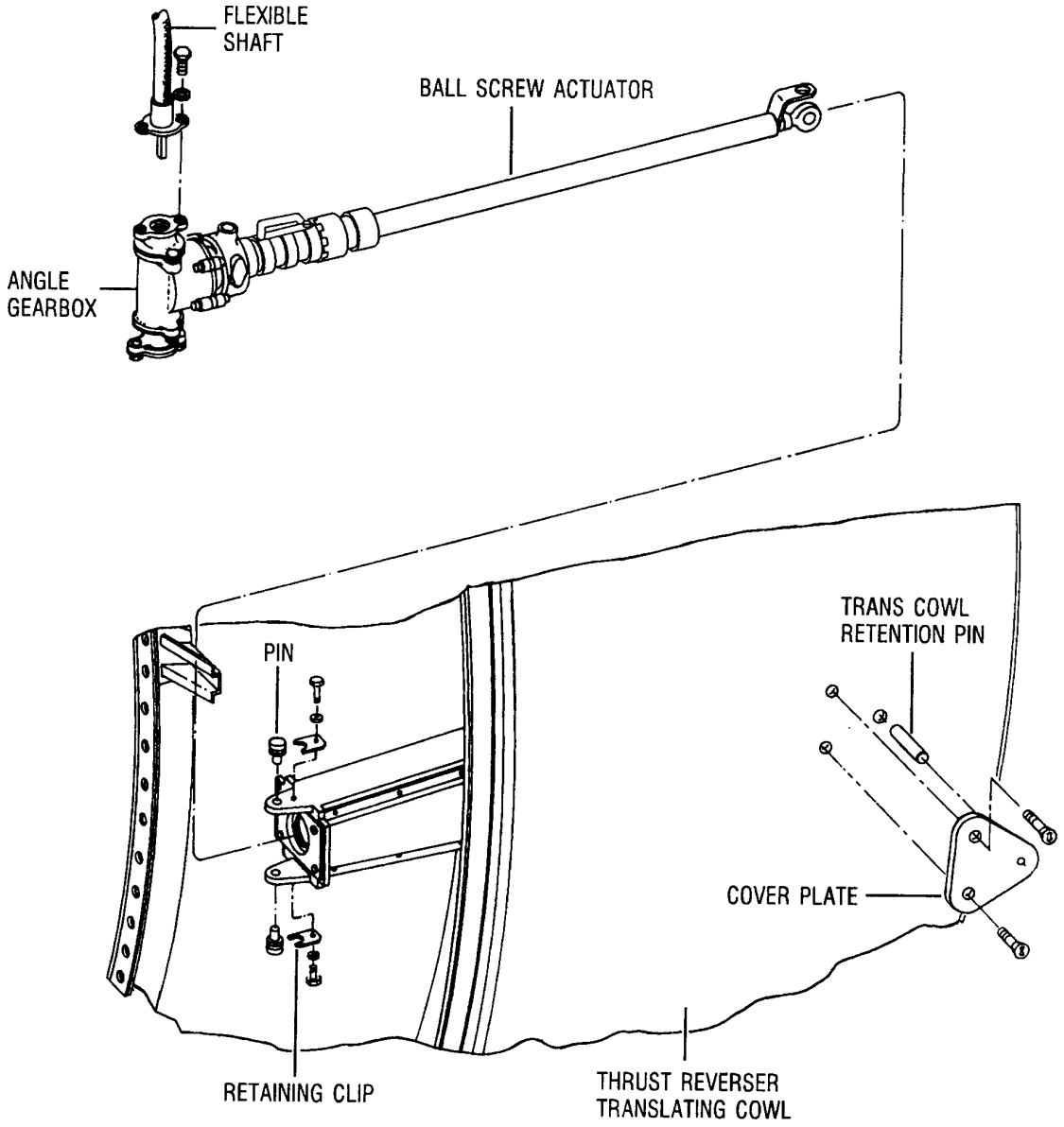
Thrust Reverser Actuation System

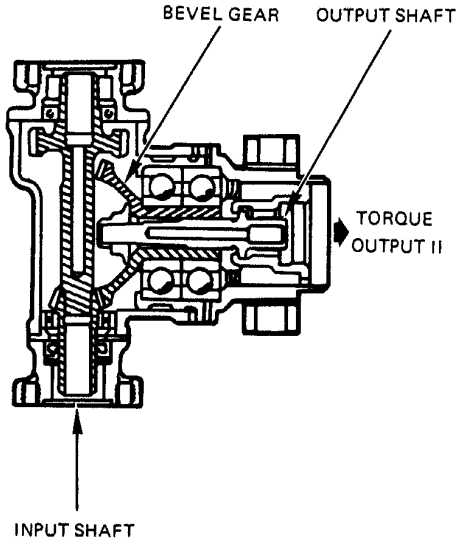


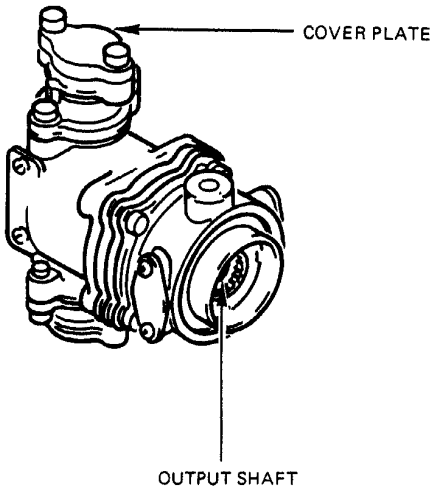
Angle Gearboxes

A gearbox is attached to the upper and lower ballscrew of each fan reverser half. They are grease-packed, zero bevel gearboxes with a speed reduction ratio of 3:1. The gearboxes incorporate two square input drives and a splined output for the ballscrew connection. The second square drive on the opposite end of the input shaft is capped; however, this connection may be used to lock the actuator or for rigging purposes. The gearbox is attached to the reverser fixed structure by a gimbal mount. The ballscrew rod end is pinned to the clevis.

Ballscrew Angle Gearbox



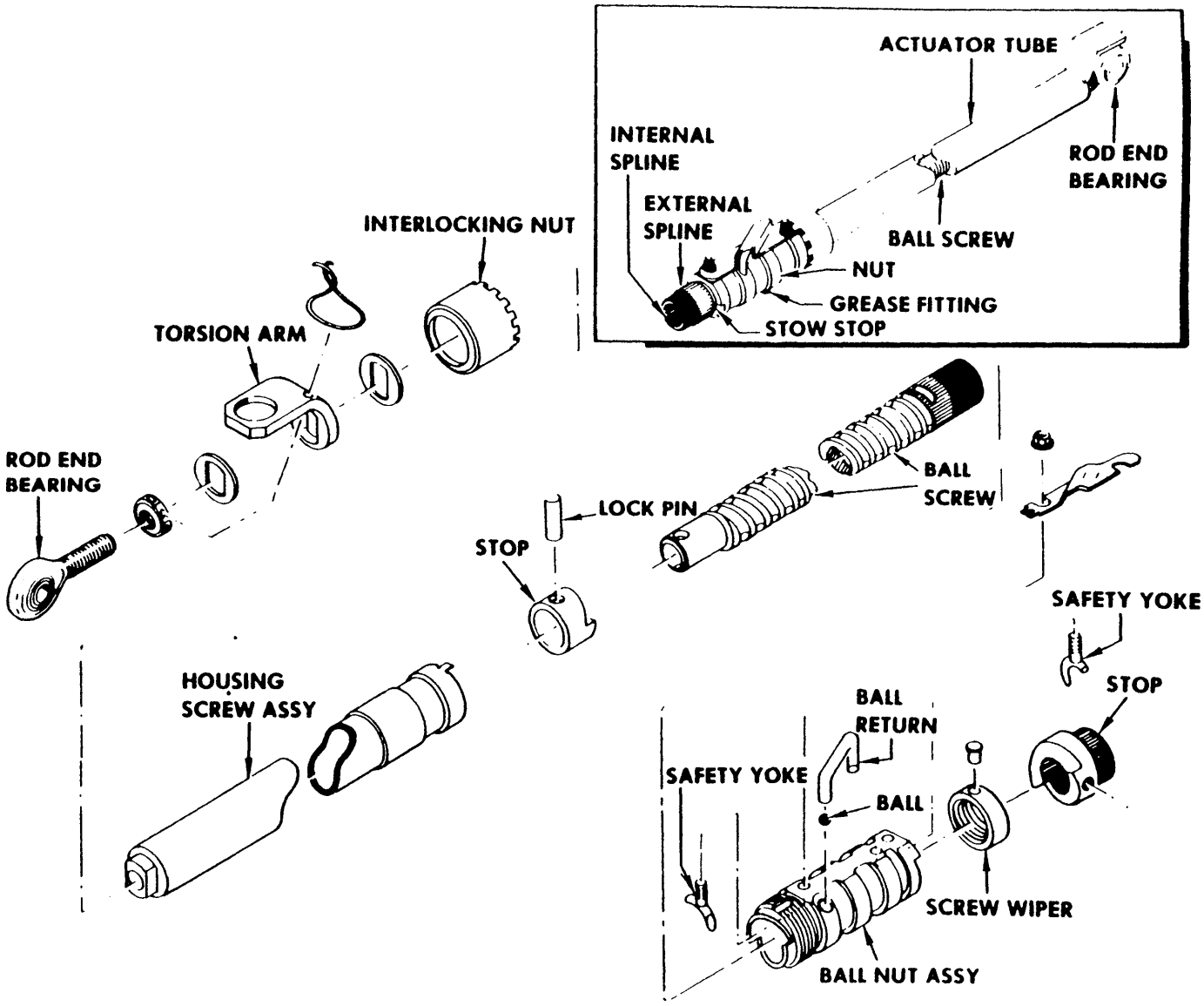




Ballscrew Actuator

Each ballscrew is spline coupled to its angle gearbox, clamped by a captive threaded nut which is locked by a splined limit stop collar. The ballscrew is rotated by the gearbox, and this action translates the ball nut. The ball nut is restrained from rotation by the torque tube housing and the torsion arm engaging a pocket of the transcowl clevis at the rod end bearing end. The deployed length is determined by a dog type stop collar pinned to the aft end of the ballscrew. The deployed limit is reached when the ball nut strikes the stop collar. The ballscrew stroke is adjustable by the captive nut of the gearbox within a narrow range. The actuator length is adjustable by the rod end bearing threaded into the aft end. The ball nut is grease lubricated.

Thrust Reverser Ballscrew Actuator



ADJUSTABLE ON OLD

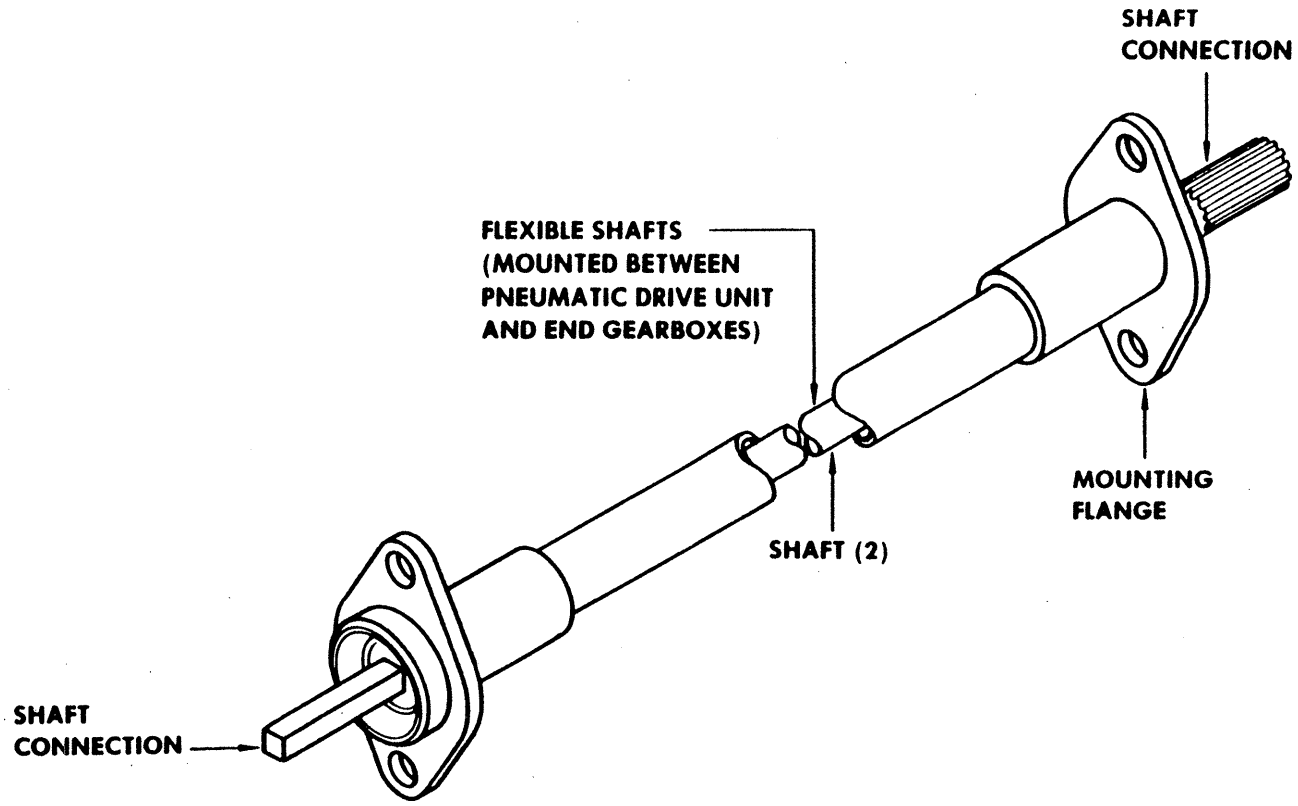
NOT ADJUSTABLE ON NEW

ADJUST COWL CAP

Flexible Drive Cables

There are four flex cables (two different lengths) interconnecting the drive ports of the CFU's with the end angle gearboxes. The inner member turns within a casing of corrosion resistant steel lined with Teflon and lubricated with grease. The inner member core is stranded music wire. It has a twelve tooth spline for rigging engagement at the CFU end while a .2 inch square end engages the angle gearbox.

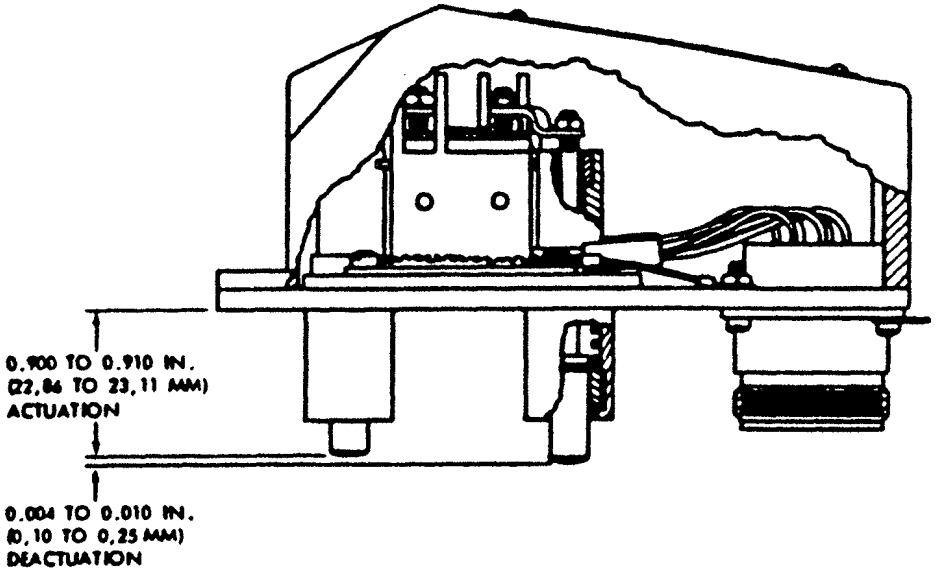
Fan Reverser Flexible Shafts

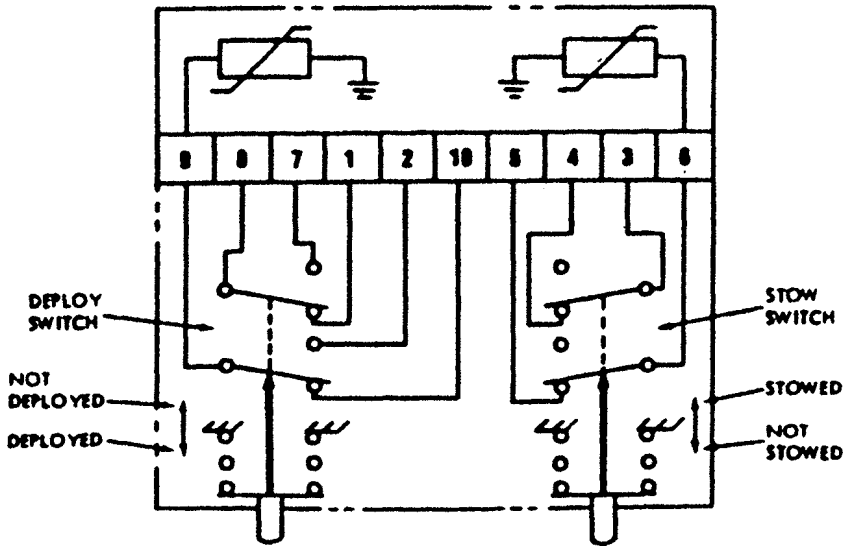


Position Indicator Switches

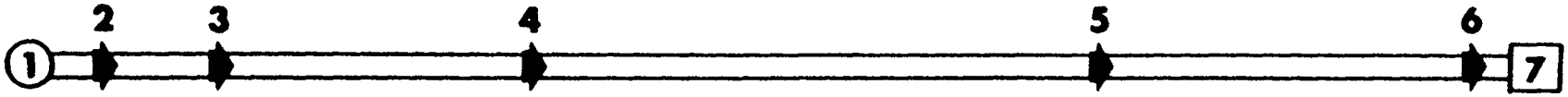
A switch assembly is installed onto each of the CDU's. The assembly contains a deploy and stow switch. They are each of the double pole double throw type. The switches are operated by motion of the stop rod mechanism. One switch changes contact within 0.3 inch of full deploy. The other switch changes within 0.2 inch of full stow. A single connector is provided for harness attachment to both switches.

Deploy/Stow Limit Switch





Deploy Stroke



1. INITIATE DEPLOY
- .RETARD THROTTLE TO IDLE
- .AUXILIARY THROTTLE TO REVERSE INTERLOCK
- .WEIGHT ON WHEELS SWITCH CLOSED

2. SYSTEM RESPONSE
- .POWER CIRCUIT ENERGIZED
- ..1/2 OF LH & RH DEPLOY SWITCHES
- ..HIGH STAGE A SOLENOID ENERGIZED
- ...PORTS ECS AIR TO SYSTEM
- ..P.R. & S.O. VALVE SOLENOID ENERGIZED
- ...REVERSER VALVE OPEN LIGHT ILLUMINATES
- ..DIRECTIONAL PILOT VALVE SOLENOID ENERGIZED
- ...DIRECTIONAL CONTROL ACTUATORS PRESSURIZED
- ....BRAKES RELEASE
- ....DIRECTIONAL CONTROL VALVE TO HIGH SPEED DEPLOY POSITION

3. DRIVE INITIATED (0.2 SEC)
- .MOTOR ACTUATORS ACCELERATE TO HIGH SPEED
- .STOP ROD MOVEMENT REPOSITIONS SWITCH CAMS
- .REVERSER UNLOCK LIGHT ILLUMINATES
- ..LH & RH STOW SWITCH IN PARALLEL TO LH DEPLOY SWITCH

4. HIGH SPEED DEPLOY MODE
- .THROTTLE FEEDBACK PROPORTIONAL TO F/R POSITION
- .FORWARD THRUST COMMAND ALLOWED AT ANY F/R POSITION

5. DECELERATION MODE
- .STOP ROD ACTUATED
- ..MOTOR EXHAUST PORT AREA DECREASES
- ...MOTOR SPEED DECREASES
- .AUXILIARY THROTTLE INTERLOCK REMOVED

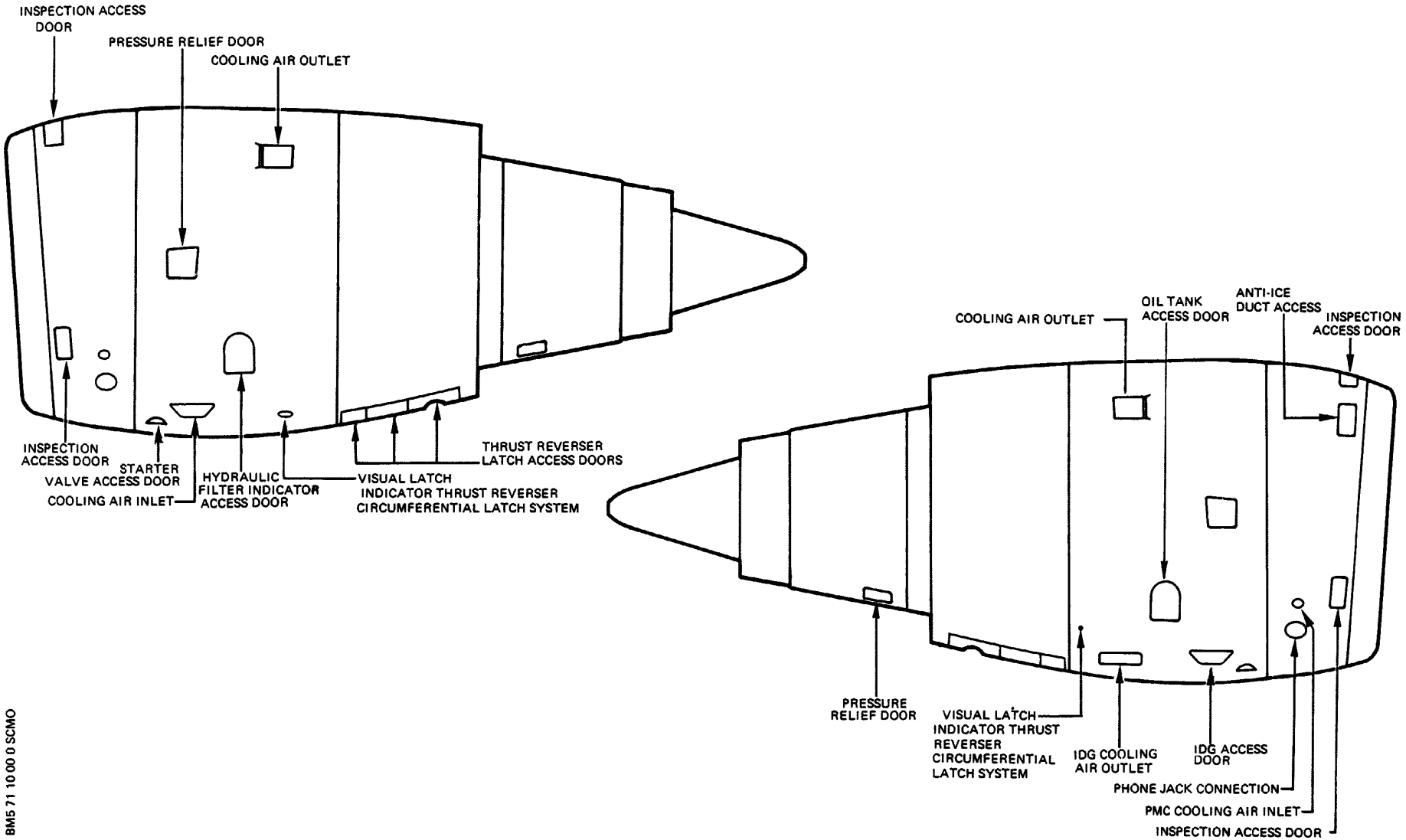
6. NEAR END OF STROKE (1/4")
- .STOP ROD ACTUATES LH & RH DEPLOY SWITCHES
- ..POWER CIRCUIT GROUND REVERSED AT LH DEPLOY SWITCH
- ...P.R. & S.O. VALVE CLOSES AIR SUPPLY
- ...REVERSER UNLOCK LIGHT EXTINGUISHED
- ...REVERSER DEPLOY LIGHT ILLUMINATES
- ..VSV RESET CIRCUIT ENERGIZED

7. FULL DEPLOY (2 SEC ELAPSED TIME)
- .AIR DUCT PRESSURE DECAYS
- ..REVERSER VALVE OPEN LIGHT EXTINGUISHES
- ..MOTOR ACTUATOR DIRECTIONAL VALVE TO STOW
- .STOP ROD TAKES TENSION IMPACT LOADS
- .AUXILIARY THROTTLE ADVANCED TO MAX REVERSE POWER

Stow Stroke

1. INITIATE STOW
   - .AUXILIARY THROTTLE LEVER TO STOW
   - ..PARALLEL POWER CIRCUITS (LH & RH STOW SWITCHES)
   - ..DIRECTIONAL PILOT VALVE CIRCUIT OPENED
2. SYSTEM STOW RESPONSE
   - .HIGH STAGE "A" AND P.R. & S.O. VALVE SOLENOID ENERGIZED
   - ..ECS AIR TO SYSTEM
   - ...REVERSER VALVE OPEN LIGHT ILLUMINATES
   - .DIRECTIONAL PILOT VALVE VENT OPENS
   - ..DIRECTIONAL CONTROL VALVE TO HIGH SPEED STOW
3. DRIVE INITIATED (0.2 SEC)
   - .MOTORS ACCELERATE TO HIGH SPEED IN STOW DIRECTION
   - .STOP ROD MOVEMENT REPOSITIONS CAMS
   - ..REVERSER UNLOCKED LIGHT ILLUMINATES (LH DEPLOY SWITCH)
   - ..DEPLOY LIGHT EXTINGUISHES
4. HIGH SPEED STOW MODE
   - .THROTTLE FEEDBACK PROPORTIONAL TO F/R POSITION
   - .DEPLOY COMMAND ALLOWED AT ANY F/R POSITION
5. DECELERATION MODE (1" FROM STOW)
   - .STOP ROD ACTUATED
   - ..MOTOR EXHAUST PORT AREA REDUCED
   - ...MOTOR SPEED DECREASES
6. NEAR END OF STOW STROKE (1/4")
   - .STOP ROD ACTUATES LH & RH STOW SWITCHES
   - ..HIGH STAGE "A" AND P.R. & S.O. VALVE SOLENOID DEENERGIZED
   - ..REVERSER UNLOCKED LIGHT EXTINGUISHES
7. FULL STOW (3 SEC. ELAPSED TIME)
   - .MOTOR ACTUATOR EXHAUST PORT OPEN 1/3
   - .STOP ROD, SEALS, BUMPERS AND FLEXSHAFTS ABSORB IMPACT LOADS PLUS MOTOR STALL TORQUE
   - .BRAKE HOLDS 1000# MIN. STOW PRETENSION
   - .DUCT PRESSURE DROPS TO ZERO
   - ..REVERSER VALVE OPEN LIGHT EXTINGUISHES
   - .FEEDBACK STROKED TO STOW POSITION
   - .MAIN THROTTLE CAN BE ADVANCED

Page 5 Alternate--from AMM


INSPECTION ACCESS DOOR
PRESSURE RELIEF DOOR
COOLING AIR OUTLET
INSPECTION ACCESS DOOR
STARTER VALVE ACCESS DOOR
COOLING AIR INLET
HYDRAULIC FILTER INDICATOR ACCESS DOOR
VISUAL LATCH INDICATOR THRUST REVERSER CIRCUMFERENTIAL LATCH SYSTEM
THRUST REVERSER LATCH ACCESS DOORS
COOLING AIR OUTLET
OIL TANK ACCESS DOOR
ANTI-ICE DUCT ACCESS
INSPECTION ACCESS DOOR
PRESSURE RELIEF DOOR
VISUAL LATCH INDICATOR THRUST REVERSER CIRCUMFERENTIAL LATCH SYSTEM
IDG COOLING AIR OUTLET
IDG ACCESS DOOR
PHONE JACK CONNECTION
PMC COOLING AIR INLET
INSPECTION ACCESS DOOR
BM5 71 10 00 0 SCMO